The primary purpose of this peer-reviewed journal is to provide a formal publication option for research completed by MSUCOM students, residents and faculty. SMRJ's mission is to advance medicine and medical education through the timely publication of peer-reviewed clinically-oriented research, clinically-relevant basic science research, healthcare quality research, and medical education research from MSUCOM and the osteopathic medicine community, with the ultimate goal of improving patient care and the education of patients and care providers. SMRJ is the official scholarly publication of the Statewide Campus System (SCS) of MSUCOM. It provides a forum for communicating research findings, clinical practice observations, philosophic concepts, and other biomedical and medical education advances to MSUCOM medical students, residents, fellows and faculty, and any other interested readers.

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Welcome to Our Sixth SMRJ Issue!

I’d like to welcome you to the sixth issue of The Spartan Medical Research Journal (SMRJ). I have the distinct pleasure of serving as your Chief Editor for this SMRJ issue.

As noted inside the cover of this issue, the purpose of this online peer-reviewed journal is to provide an accessible formal publication option for research & QI papers and case reports from Michigan State University COM students, residents, fellows and faculty and associates. We continue to receive submissions from both Statewide Campus System (SCS)-affiliated and non-affiliated authors from other parts of the country and our readership continues to grow!

Now that our SMRJ has been online for 24 months, we have submitted an application for PubMed article number assignments and journal indexing through the US Library of Medicine. We hope to have this application reviewed in October, 2018 and will keep all SMRJ authors and SCS-affiliated readers apprised of this process!

We at the SCS continue to be dependent on a large number of expert reviewers for SMRJ submissions. We are still recruiting expert reviewers from all medical specialty areas to be members of the Editorial Board. If you have an interest in participating as a reviewer, please contact Chief Editor Corser.

If you have comments or suggestions, please contact any of our editorial team members at any time. Please remember that we also accept Letters to the Editor.

We hope that you enjoy this issue!

Sincerely,

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Quality Improvement Project

Implementation of an Antibiotic Therapy Protocol for Open Fractures in the Emergency Department

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ABSTRACT

ENDRES T, DANIELSON K, O’NEILL S, BRANDENBURG S, HALL T, ROSS H. Implementation of an Antibiotic Therapy Protocol for Open Fractures in the Emergency Department. Spartan Med. Res. J. Vol. 3, No. 2, pp. 01-14, 2018. CONTEXT: Well established in the Emergency Department (ED) literature is that the most important factor in decreasing subsequent infection rate in open fractures is the time to first administration of antibiotics. As such, the authors developed a new ED open fracture antibiotic protocol to facilitate more expeditious antibiotic administration and appropriate choice of antibiotics. METHODS: During Phase 1 of this project, the authors identified the 2012 - 2016 historical length of time from presentation of an open fracture to the possible initiation of antibiotic therapy at their institution. Results demonstrated critical areas for improvement in both timing and types of antibiotics administered. Phase 2 of the study evaluated the effect of the new open fracture antibiotic protocol. Sample cases from both phases were then further identified based on type of open fracture, time to initiation of antibiotics from ED presentation, type of antibiotics, and time to definitive treatment. Analyses were performed using GraphPad proprietary software. RESULTS: A random sample of 110 patients were included from Phase 1 and 27 patients from Phase 2. A total of 43 Phase 1 patients were administered cefazolin (Kefzol, Ancef); the remainder of the patients received a number of different antibiotics. During Phase 2, all 27 patients received cefazolin and Gentamycin if necessary per the new protocol. The average time to initiation of antibiotics was 0.907 hours during Phase 1 compared to 0.568 hours in Phase 2. The new protocol also significantly decreased the average time to antibiotics in ED from 2.17 hours to 1.82 hours when including EMS transfer time. Average time to definitive treatment in the operating room was 6.63 hours during Phase 1 and was significantly lowered to 3.97 hours during Phase 2. CONCLUSIONS: Timing to initiation of antibiotics after open fractures is the most important aspect to decrease infection rates. In order to decrease these times, the authors implemented a new ED protocol that specifically stated the type of antibiotic to be given based on the open fracture without orthopedics needing to be notified before administration. Ideally, the use of such protocols in ED settings will serve to greatly decrease infection risks after open fracture. Keywords: open fracture, orthopedics, emergency department trauma, antibiotics.
INTRODUCTION

A recent upgrade to a certified Level 2 trauma center at the author's institution (Michigan-based Metro Health) accentuated emergency department (ED) providers' awareness of the importance of high quality care for their trauma patients. A Level 2 trauma center hospital is able to initiate definitive care for all injured patients and includes 24-hour coverage by the specialties of orthopedic surgery, trauma surgery, neurosurgery, anesthesia, emergency medicine and critical care. One common type of traumatic injury seen in ED settings is an open or “compound” bone fracture in which there is also an open wound or break in the skin.

It has been established in the medical literature that the most important factor to decrease later infection rates in open fractures is the time to administration of antibiotic therapy. Until 150 years ago, an open fracture was associated with high morbidity and often resulted in amputation. Despite improvements in sanitization and hemorrhage, mortality rates continued to be high. An early 1881 study by Billroth noted that more than half of the patients in a study with 93 open fractures died due to sepsis.

As medical research continued, the advances by Pasteur, Koch and Lister noted large advancements in patient survival outcomes. They advocated for limb splinting and wound extension with excision and debridement procedures that yielded favorable outcomes. There has continued to be improvement and better outcome prediction with open fracture management and notable advancements as it pertains to successful fracture reduction and fixation along with serial irrigation and debridements.

With an improved understanding of the optimal treatment of open fractures, a way to categorize them was needed. A fracture classification defined by Gustilo and Anderson was one of the first and remains most widely accepted. According to this framework, open fractures are classified by Types I-III, with Type III being further classified based on soft tissue coverage and degree of vascular compromise.

In 1976, Gustilo and Anderson reported a series of 673 open fractures of long bones treated from 1955 to 1968 with infection rates varying between 12% (1955-1960) and 5% (1961-1968). In this group's later 1984 prospective study, 352 patients were managed as follows: debridement and copious irrigation, primary closure for Type I and II fractures and secondary closure for Type III fractures, no primary internal fixation except...
in the presence of associated vascular injuries, cultures of all wounds, and oxacillin-ampicillin before surgery and for three days postoperatively. To compare the two periods, the infection rates were 44% in the first retrospective study and 9% in the later prospective study for Type III open fractures (severe soft-tissue injury, segmental fracture, or traumatic amputation).

The recent literature on open fracture management has continued to reinforce that the most important variable for open fracture management is timely administration of antibiotic therapy. In their 1989 article, Patzakis and Wilkins reported an infection rate of 4.7% when antibiotics were administered within three hours of open fracture injury, compared to 7.4% when the treatment was delayed.

**Purpose of Project**

The goal of this quality improvement project was to examine the relative effects of an ED antibiotic administration protocol for open fracture patients at the authors' institution. Specific objectives were to evaluate the effect of the new protocol to decrease the time to first antibiotic administration, and standardize the type of antibiotics administered for open fracture patients.

**METHODS**

IRB approval had been obtained from the author's institution before data collection was begun and the authors followed the PDSA model (Plan, Do, Study, Act) to plan the project. More specifically, Phase 1 consisted of the “Plan” and “Do” aspects of the model, while Phase 2 consisted of the “Study” and “Act” aspects of the model.

During Phase 1, the authors completed a retrospective chart review using ICD-9 codes (all open fracture ICD-9 codes used during an EHR search) to isolate open fracture diagnosis patients in the ED from a certain time period. Inclusion criteria included ICD-9 code for open fracture from December 2012 through December 2016. Exclusion criteria included evaluation and treatment at another institution for the same fracture prior to arrival. Statistical analyses were performed by a local campus-based statistician (see acknowledgements) using Graph Pad proprietary software. Phase 1 results demonstrated critical areas for improvement in both decreasing time to antibiotic therapy as well as consistency among antibiotic choices in the setting of open fractures. With
these results, a new antibiotic administration protocol for open fractures was developed before Phase 2 and put on display in the authors ED, with the new protocol also incorporated into the institution’s electronic health record (EHR).

**New Antibiotic Administration Protocol**

The new antibiotic administration protocol for open fractures worked as follows. If a patient arrived to the ED with an open fracture, the ED attending physician typed open fracture into orders in the Epic EHR chart. A list then appeared so that the attending physician could simply click on the type of open fracture and from there indicated antibiotics were pre chosen. For example, if a patient came in with a fracture with puncture wound (wound less than 1.0 centimeter (cm) associated with it, then the ED attending typed in open fracture and clicked on the choice for puncture wound (wound less than 1.0 cm): 2 grams (gm) cefazolin (Kefzol, Ancef), and the antibiotic was immediately administered.

If the wound appeared to be greater than 1.0 cm, then the ED attending clicked that option and Gentamycin 5mg/kg was added to the patient’s antibiotic regimen to ensure proper gram-positive and gram-negative bacterial coverage. If the injury was a suspected farm injury, Penicillin G was added to the regimen without the ED attending having to distinguish between contaminated or clean wounds. This also eliminates the need for the ED attending physician to differentiate between the types of Gustilo’s classification of open fractures and still provide adequate antibiotic coverage. If the patient was allergic to Penicillin, Vancomycin 15mg/kg (dosage per weight) could have been administered as an alternative (Figure 2).

Frequently, patient weight was not obtained in a timely fashion in a trauma code, therefore instead of using weight-based dosing for cefazolin, a dose of 2 gm was chosen for simplification of antibiotic dosing for expeditious administration. This study excluded pediatric open fractures and therefore pediatric dosing of antibiotics.

Finally, during Phase 2 a second review was performed one year after implementation of the new antibiotic protocol. The charts of eligible sample patients were randomly chosen based on project exclusion and inclusion criteria. Inclusion criteria included ICD-9 code \(^7\) for open fracture from December 2016 to December 2017. Exclusion criteria included evaluation and treatment at another institution for the same
fracture prior to arrival. The authors further evaluated cases based on type of open injury per the Gustilo/Anderson classification, Type 1, 2, or 3; time to initiation of antibiotics from ED presentation; type of antibiotics; and time to definitive surgical treatment.

RESULTS

Phase 1: December 2012-December 2016 (before new protocol)

Of the charts identified per the inclusion criteria, a total of 118 patients were included in analyses. Of those 118, eight (6.8%) were miscoded as an open fracture, leaving 110 patients included in the retrospective review. Of the 110 fractures, 25 (22.7%) were Gustilo Type 1; 36 (32.7%) were Gustilo Type 2, and 12 (11.0%) were coded as Gustilo Type 3; 9 (8.2%) as Type 3A and 1 (0.09%) as Type 3B, and 2 (1.8%) as Type 3C. The remaining 37 (33.6%) were coded as open fractures with no distinction.

In addition, the types of antibiotics administered were also recorded; 43 (75.4%) patients were administered cefazolin 1 gm intravenous (IV); two (1.8%) patients were administered cefazolin 2 gm IV; two (1.8%) patients were administered cefazolin 1 gm intramuscularly; 19 (17.3%) patients were administered Ancef 1 gm IV and Gentamycin 250 mg IV; one (0.09%) patient was administered Augmentin orally; and one (0.09%) patient was administered Ceftriaxone 1 gm IV. The other combinations of antibiotics that were administered during Phase 1 are listed in Table 1.

Patients' average length of hospital stay was reported as 2.63 (SD 4.082) days. Average time to definitive treatment in the operating room from initial ED presentation was 6.63 hours ranging from one to 26 hours. The average time to initiation of antibiotic administration for open fractures after ED presentation was 0.907 hours, ranging from 0.10 to 3.10 hours. These time estimates did not include time from injury to presentation to the ED.

According to the National Emergency Medical Services Database, response time to scene is 14 minutes on average; scene time is 40 minutes on average; transport time is 22 minutes on average. This totals 76 minutes on average. This additional time should be considered by providers in the ED when assessing open fractures and an accurate time from injury to initiation of antibiotics should be documented.
Phase 2: December 2016-December 2017 (after protocol)

During this phase, 35 eligible patients were identified. Of those 35, eight (22.8%) were miscoded as an open fracture, leaving a total of 27 patients included in the retrospective review. Of these 27 fracture patients, 11 (40.7%) were Gustilo Type 1; seven (26.0%) were Gustilo Type 2 and nine (33.3%) were coded as Gustilo Type 3 (eight as Type 3A, zero as Type 3B, and one as Type 3C).

Data concerning the type of antibiotics administered as a deviation from current protocol was also collected. Twenty five (93.0%) of Phase 2 patients were administered cefazolin IV plus Gentamycin, if appropriate, per protocol. Two patients were considered outliers, one patient who was administered Unasyn and one patient who received Zosyn. Of these two patients who were not administered cefazolin, the ED staff switched them to cefazolin per protocol within one and two hours respectively, therefore they met criteria of the phase 2 protocol. Therefore, 27 (100%) of Phase 2 patients received appropriate antibiotic treatment. (Table 2) This is compared to Phase 1, which was before the new antibiotic protocol for open fractures was in effect, in which appropriate antibiotic use was only seen in 66 of 74 (89%) of patients (p > 0.05). (Table 1)

Length of stay in the hospital averaged 4.9 days in Phase 2 compared to 2.63 days during Phase 1. This finding could be explained by variations in the severity of the fractures and need for multiple procedures. Average time to definitive surgical treatment from initial ED presentation was 3.97 hours (SD 2.506) during Phase 2 compared to 6.63 hours (SD 5.490) during Phase 1 (p < 0.05), ranging from 1.30 hour to 8.43 hours. Also important to note is that no Phase 2 sample patients waited longer than four hours for definitive surgical treatment (Graph 1), although the authors did not attempt to correlate this measure with initiation of timing to antibiotic administration.

In Phase 2, the average time to initiation of antibiotics for open fractures after ED presentation was 0.568 hours (34 minutes) (SD 0.4556), ranging from 0.1 to 2.2 hours (6 minutes to 132 minutes). This is compared to Phase 1, which was 0.907 hours (54.4 minutes) (SD 0.7356) ranging from 0.1 to 3.1 hours (6 minutes to 186 minutes) (p < 0.05) (Graph 2).
DISCUSSION

The initiation of antibiotic therapy after an open fracture has been proven to be the most important factor in preventing perioperative infection. Patzakis et al (2000) conducted a prospective study that showed a statistically significant reduction in infection rates attributed to the administration of ciprofloxacin compared with no antibiotic administration after open fractures. Additionally, this group found a considerable reduction in infection rates when antibiotics were administered less than three hours after injury compared with longer than three hours after injury (4.7% versus 7.4%).

Similarly, Lack and colleagues (2015) also reported that time to antibiotic administration was predictive of infection. Cefazolin was the only agent given in 93.4% of cases. The overall deep infection rate was 17.5%. Patients who received antibiotics within one hour of injury had a 6.8% infection rate compared with 27.9% in those receiving antibiotics after 90 minutes.

One of the shortcomings of the Gustilo and Anderson classification includes lack of inter-observer reliability. In fact, Brumback and Jones (1994) recommended delaying fracture classification until the first operative debridement. As more data suggest that time to debridement is not predictive of infection, the average time to debridement is likely to increase. If time to debridement increases, then time to classification and appropriate antibiotic treatment could be delayed. In addition, since the importance of the time to antibiotic administration with effective gram-negative coverage has not yet been well established, we used this possible complication to adjust our specific open fracture antibiotic protocol.

It was very important to the authors that after implementation of our Phase 2 protocol, all patients received antibiotic therapy within three hours (100% compliance) from time of injury. Based on the results of Patzakis et al. along with the results observed in this study (Graph 2), suggests that our Phase 2 patients were at decreased risk for infection when compared to the relatively delayed time to antibiotics administration during Phase 1.

Finally, the initial Phase 1 data clearly demonstrated there was no uniform protocol for specific antibiotic used in the ED at this institution. Although a majority of sample patients treated before the protocol received cefazolin 1 gm IV (75.4%), there were still
roughly 25% of patients who received a variety of antibiotics. After the initiation of the protocol, all open fractures were appropriately administered cefazolin and/or Gentamycin.

According to Sirkin, for low-grade (I and II) open fractures, antibiotics should be directed at mainly gram-positive and some gram-negative coverage. A first-generation cephalosporin, such as cefazolin, should be used. A 2-gm loading dose is given, followed by 1 gm every eight hours. For the higher-grade fractures (III-A and III-B), the treating physician must worry more about gram-negative coverage. An aminoglycoside (Gentamycin or Tobramycin) must be added to help prevent these types of infections.

For grade III-C fractures (e.g., limbs with poor vascular status and farm injuries), the presence of anaerobes is more likely. In addition to a cefazolin and Gentamycin, aqueous Penicillin G 4 million units every four hours should be added. The duration of antibiotic therapy has historically been seven to 10 days. Most likely this was recommended to simulate the duration of wound healing. Although definitive evidence is not presently available, current recommendations for uncomplicated, grade I or II fractures is antibiotic coverage for 24 to 48 hours after wound closure. For grade III fractures, this should be extended to 48 to 72 hours after definitive wound closure.

When evaluating the data from Phase 2 of this study, we recognize that some patients may not have been appropriately administered tetanus toxoid or immunoglobulin according to Centers for Disease Control (CDC) recommendations. If a patient has had more than a 10-year lapse in a tetanus booster or if a patient is immunocompromised they should be administered both the toxoid and the immune globulin (250 – 500 IU). The authors have noted this would be an easy future additional element for the protocol based on the patient’s immunization status.

Furthermore, this study reinforces the tenets of osteopathic medicine. Providers should consider that an open fracture is not just an isolated event, but an inciting event that can have further health repercussions when not addressed in a timely and appropriate manner. Potential repercussions include further need for surgical intervention, osteomyelitis, bacteremia, sepsis and even death. As demonstrated in osteopathic principles, this highlights the principle that the body is a unit and the interrelationship of structure and function. By treating open fractures with appropriate
antibiotics as soon as possible, physicians can decrease the risk of patients developing such adverse events.

CONCLUSIONS

In summary, timing to initiation of antibiotics after open fractures has been shown to be an important aspect to decrease infection rates in multiple prospective studies. As previously stated, the 2015 Lack study found lower incidence of infection in grade III injuries if antibiotics were administered less than 66 minutes after injury. However, most experts recommend less than three hours post-injury for the majority of open fractures as the ideal goal for initiation of antibiotics. The type of antibiotics given has also been proven in multiple articles.

At the author’s specific institution, the average time to initiation of antibiotics had been about 2.17 hours from time of injury with some patients waiting as much as 4.36 hours, prior to surgical intervention. In response, a new protocol for administration of clinically indicated antibiotics for open fractures in the ED was implemented at the author’s institution in December 2016, leading to a decrease in time to initiation of antibiotics.

The further development and testing of open fracture protocols can decrease provider confusion and discrepancies among attending ED physicians and residents. In further testing, the incorporation of additional key elements such as tetanus toxoid being added to the protocol and standardized antibiotic prescribing practices can serve to improve care in this complex aspect of orthopedic trauma care.

The authors report no external funding source for this study.
The authors declare no conflict of interest.
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Project analyses were conducted by Allen Shoemaker, PhD: Calvin College.
The overall results of this project were presented at a 2017 Michigan Orthopaedic Society meeting.
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13. Sirkin, Michael MD. Compartment Syndromes and Open Fractures. Core Knowledge in Orthopaedics: Trauma, Chapter 1. 1-17.
TABLES AND FIGURES

**Figure 1**
Gustilo-Anderson Open Fracture classification

<table>
<thead>
<tr>
<th>Classification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type 1</strong></td>
<td>Puncture wound of less than or equal to 1.0 cm with minimal soft tissue injury</td>
</tr>
</tbody>
</table>
| **Type 2**     | Wound is greater than 1.0 cm in length  
                  Moderate soft tissue injury  
                  Soft tissue coverage of the bone is adequate  
                  Comminution is minimal |
| **Type 3A**    | Extensive soft tissue damage  
                  Includes massively contaminated, severely comminuted or segmental fractures as well as farm injuries  
                  Soft tissue coverage of the bone is adequate |
| **Type 3B**    | Extensive soft tissue damage with periosteal stripping and bone exposure  
                  Severely contaminated and comminuted  
                  Flap coverage is required to provide soft tissue coverage |
| **Type 3C**    | Associated with an arterial injury requiring repair for limb salvage |
Figure 2
Algorithm for Open Fracture Antibiotic Initiation in the Emergency Department

1. Suspected Open Fracture arrives in ED

2. Immediately administer Ancef 2 gram loading dose

   (If allergic to penicillin analogues: Give vancomycin 15mg/kg)

3. If wound is larger than a puncture wound (greater than 1cm): add Gentamycin 5mg/kg. If farm injury suspected, add PCN G

4. After initiation of antibiotics: may then proceed to further imaging and discussing case with orthopedic surgery
Graph 1
Time from Arrival to Definitive Fixation in the Operating Room

Graph 2
Time from Arrival to ED to Antibiotic Administration
Table 1
Types of Antibiotics Prescribed During Phase 1

<table>
<thead>
<tr>
<th>Antibiotic</th>
<th># of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ancef 1 gram IV</td>
<td>(75.4%) 43</td>
</tr>
<tr>
<td>Ancef 2 gram IV</td>
<td>2</td>
</tr>
<tr>
<td>Ancef 1 gram IM</td>
<td>2</td>
</tr>
<tr>
<td>Ancef 1 gram IV and Gentamycin 250 mg IV</td>
<td>19</td>
</tr>
<tr>
<td>Augmentin PO</td>
<td>1</td>
</tr>
<tr>
<td>Ceftriaxone 1 gram IV</td>
<td>1</td>
</tr>
<tr>
<td>Clindamycin 600 mg IV</td>
<td>1</td>
</tr>
<tr>
<td>Keflex 500 mg PO QID</td>
<td>1</td>
</tr>
<tr>
<td>Rocephin 1 gram IV</td>
<td>3</td>
</tr>
<tr>
<td>Vancomycin 2 grams IV</td>
<td></td>
</tr>
</tbody>
</table>

Table 2
Types of Antibiotics Prescribed during Phase 2

<table>
<thead>
<tr>
<th>Gustilo Classification</th>
<th>Antibiotics Administered</th>
<th># of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>Ancef IV</td>
<td>11</td>
</tr>
<tr>
<td>Type 2</td>
<td>Ancef plus Gentamycin IV</td>
<td>7</td>
</tr>
<tr>
<td>Type 3</td>
<td>Ancef plus Gentamycin IV</td>
<td>9</td>
</tr>
</tbody>
</table>

No farm injuries during Phase 2.
Project to Improve the Transcription of Clinical Order Information into a Radiology Information System

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ABSTRACT

MILLS MJ, NGUYEN JX, HIMELHOCH B, SOUALA A, KHASHOLA A, JOSEPH S, RATHOUSKY P, GONDA R, JUAN MCY. Project to Improve the Transcription of Clinical Order Information into a Radiology Information System. Spartan Med. Res. J. Vol. 3, No. 2, pp. 15-28, 2018. CONTEXT: Inaccurate and incomplete imaging order information presented to interpreting radiologists is a persistent problem in many radiology settings. Computerized Physician Order Entry processes in clinic-based settings are often inconsistent, and radiology transcription clerks continue to play a critical role in transmitting accurate content and information from referring physician orders to the radiology information system. (RIS) The purpose of this quality improvement project was to a) identify common transcription areas of deficient RIS imaging order information and b) test outcomes from an intervention to improve the content and concordance of transcribed patient information entered into the RIS.

METHODS: A random convenience sample of 500 outpatient radiographic orders were categorized according to degree and quality of concordance between the transcribed patient information documented in the RIS and the corresponding original imaging order information. During Phase I, the authors used a root-cause analysis to determine the possible etiologies for discordance between the information in original imaging orders and the information transcribed into the RIS. The intervention that was delivered included a short education session with radiology transcription clerks with placement reminder posters at transcription workstations. During Phase 2, a second random sample was obtained following the intervention, with data collection and analyses replicating the process from Phase I. A set of inferential comparisons were conducted using chi-square tests to examine for statistical significance.

RESULTS: There was an overall 44% decrease in transcription discordance (p < 0.001), and the number of cases with perfectly concordant RIS order indication documentations increased by 21% (p < 0.001). A total of 34% of transcriptions from Phase I were partially discordant due to an inadequate imaging study indication, compared to 15% during Phase II (p < 0.001).
There was also a 22% increase in the number of completely concordant transcriptions free of grammatical errors (p < 0.001). **CONCLUSIONS:** A short education session with radiology transcription clerks along with placement of reminder posters may significantly improve both the concordance and quality of transcribed imaging order information presented to interpreting radiologists using the RIS. **Keywords:** imaging order transcription, radiology information system, quality improvement

**INTRODUCTION**

The transcription of inaccurate and incomplete radiologic imaging order information remains a persistent problem in many settings. The entry of accurate information concerning the indications for an imaging order (i.e., reason radiologic procedure was ordered) and adequate patient history can impact the quality of reports, frequently affecting patient safety and imposing billing problems. Prior studies have revealed that as many as 30% of imaging order requisitions can lack adequate clinical order indications, and up to 24% can lack vital patient information for proper image interpretation.

Radiology transcription clerks remain important personnel responsible for recognizing both grammatical and content imaging order errors. Transcription clerks also play a critical role in determining which information to transfer from the original imaging order into radiology information systems (RIS).

Computerized physician order entry (CPOE) is a major functionality that could potentially mitigate errors made by radiology transcription clerks. However, the literature reveals that by 2004 only 10% of US institutions had fully implemented a CPOE system. By 2015, this proportion had only increased to 15.7%. Numerous radiologist authors have discussed the importance and necessity of improving the imaging order information presented to the radiologist through use of CPOE software systems.

However, there appear to have been few studies examining the transcription of imaging order information to a RIS after implementation of CPOE. The systematic testing of interventions to improve transcription of order imaging information to date has also been rare. In one study, however, educating transcription clerks, supplemented by a checklist, was shown to significantly improve, from 46.4% to 62.8% “perfect” concordance, of the information presented to interpreting radiologists.
At the authors’ community-based institution, CPOE has been implemented for hospital radiology imaging orders with direct population of order information into the RIS. At the time of this project, this was not the case for the institution’s clinic-based orders. When patients presented for clinic imaging, they provided a registration clerk with a hard copy imaging order requisition from the referring physician. These forms could either be standardized fillable forms or written narrative note prescriptions. A radiology transcription clerk then manually transcribed the imaging order information into the RIS. Picture archiving and communication system (PACS), Merge RadSuite was also used to convey imaging order indications, the imaging modalities ordered, and other pertinent patient information to the radiologist who later interpreted the imaging results. An overview of the general process at the authors’ healthcare system is depicted in Figure 1.

Similar to other settings, the authors had ongoing key problems related to the transcription process in this setting including the entry of inaccurate or incomplete information from the image requisition form into the RIS, grammatical transcription errors, and an inadequate amount of clinical patient history. These errors ranged from minor grammatical errors and misspellings, to inappropriate abbreviations, missing patient information, and some absent information or random typographical errors.

These types of errors can potentially lead to compromised patient safety and diminished efficiency for the radiology practice, which in turn can be associated with unnecessary loss of time and aberrant radiologic reports being sent back to the referring physician. Finally, billing and coding staff use this information for revenue recovery, and incomplete transcription information can also delay system reimbursements.

**Purpose of Project**

Our two-phase quality improvement (QI) project was conducted to: a) identify common transcription areas of deficient RIS imaging order information (Phase I) and b) test outcomes from an intervention to improve the content and concordance of transcribed patient information entered into the RIS (Phase II).

**METHODS**

After project approval was obtained from the Providence-Providence Park Hospital Institutional Review Board, Phase I of the project was conducted with the goal of
examining the extent of discordant information found between imaging orders and information entered into the RIS. The authors utilized retrospective chart review from both the PACS and RIS systems to identify the most common sources of transcription errors. Data from a random sample of 500 subjects were gathered from the imaging orders, RIS documentation and the PACS. The subjects included in this first phase had received clinic-ordered imaging studies from September 1 - October 1, 2016. Studies reviewed included radiographs, computed tomography, magnetic resonance imaging, and nuclear medicine studies.

The image order documentation, consisting of either a form generated by a computer at the referring physician’s office, or a written prescription from the ordering physician, was scanned directly into the PACS system and reviewed by authors BH, AS, AK, and MCYJ under the supervision of authors MJM and JXN. The clinical information from these documents, as previously transcribed to the RIS for review by the interpreting physician, was also reviewed by the same authors. This information was cross-referenced by these same authors to assess the degree and quality of concordance between the image order documentation and the RIS presented to the interpreting physician. More specialized imaging studies ordered in the hospital setting and/or completed through the interventional and fluoroscopy radiology service were excluded from the analytic sample.

**Phase I: Historical Review of RIS Order Information**

Upon their initial review of sample records, it was clear to the authors that the greatest source of incomplete or inaccurate RIS order information was related to transcription clerk errors. For this study, the authors used the general three-category approach of DiRoberto, Lehto and Baccei (2016) to gauge concordance levels in RIS data between the two study phases. Imaging studies were categorized as “concordant” if the information matched verbatim and as “partially concordant” if the RIS did not contain all of the information present in the imaging order form. Imaging studies were categorized as “discordant” if a substantial amount of necessary information was missing in the RIS, or if the RIS clearly contained incorrect information or typographical errors. Classification decisions were based on clinical judgement and agreed upon by all authors.

Concordant and partially concordant imaging orders were also assessed for quality of concordance. Quality of concordance was categorized as “highest” if transcribed
information matched the clinical order verbatim, contained a complete and informative patient history, and was free of any grammatical errors. The quality of concordance was categorized as “high” if transcribed information was concordant but contained grammatical errors (e.g., incorrect capitalization, non-standard abbreviation, misspellings or misused punctuation). The quality of concordance was categorized as “low” if information in the RIS was partially concordant with the actual imaging order but failed to provide a complete or accurate patient history. Also categorized as low concordance were records with significant grammatical errors and/or omissions that contained ambiguities that could not be readily interpreted by the RIS auditor.

Following Phase I, a meeting was conducted with four administrators, the authors, and the department chair. A root-cause analysis, shown in Figure 2, was used to determine the possible etiologies for transcription discordance between the imaging order information and the information transcribed into the RIS.

**Project Intervention**

Based on the authors’ Phase I findings, transcription process errors were chosen as the target of intervention. The intervention included an initial staff meeting in June 2017 to inform radiologists of the QI project. A detailed email was also routed to all radiology transcription clerks, emphasizing their ongoing attention to accurate and complete transcription of imaging order information. Examples of correct and full transcriptions were presented (Appendix 1).

In addition, an 8 x 11 inch poster including a checklist for verbatim transcription of content, grammatical checking, and spell checking was placed at each transcription workstation (Appendix 2). A reminder was also included as part of regular mid-month department meetings and emails.

Following the intervention, Phase II of the study entailed the same data collection process as Phase I. The subjects included in Phase II of the study had received clinic-based imaging orders between June 1 to July 1, 2017. Again, more specialized imaging studies completed in the hospital setting and/or through the interventional and fluoroscopy radiology services were excluded from the analytic sample. Data from both the image requisition and RIS documents were again extracted on the same variables
and cross-referenced by the data collector to assess their degree of transcription concordance. Inferential comparisons utilizing chi-square statistical testing were utilized. Two PhD-prepared researchers (see acknowledgements section) at the first author’s healthcare system used SPSS™ version 24.0 statistical software to conduct analyses.

RESULTS

A total of 266 (60%) of Phase I imaging order documentation records were found to be perfectly concordant, meaning that the content provided for the indication and clinical history was identical between the imaging order and RIS documentation. Phase II demonstrated 374 (81%) perfect concordance, a 21% post-intervention increase (p < 0.001). A total of 121 (34%) of RIS documents from Phase I were partially discordant, meaning the order indication and patient history information was partially but inadequately transcribed compared to 68 (15%) during Phase II (p < 0.001). A total of 24 (6.0%) Phase I RIS documents were discordant, meaning substantial information was missing, compared to 19 (4%) during Phase II (p = 0.271). Overall, the number of partially or completely discordant documents decreased by 44% after intervention (p < 0.001) (Figure 3).

Regarding overall levels of transcription concordance, there was a 22% (169 pre-intervention and 265 post-intervention) increase in the number of transcriptions that demonstrated the highest level of concordance (p < 0.001) (Figure 4). For the remainder of sample cases, there were substantial grammatical errors made during imaging order transcription into the RIS. These problems could be attributable to either the imaging order information having been entered manually, with lack of an electronic spell check function within the RIS documentation software, or variable medical terminology training/experience among radiology transcriptionists.

Observed concordance errors included omissions of specific clinical information provided by the referring physician, for example the clinical order said “shoulder pain” while the transcribed information on the RIS said “pain.” There were also inappropriate abbreviations used, such as “PE” substituted for “pulmonary embolism” which could also be interpreted as “pleural effusion.” Other RIS forms omitted relevant information that was present on the original imaging order, such as the site/side of injury, symptoms
provided by the referring physician, or their specific concerns regarding the suspected clinical pathology. Other spelling and grammatical errors were observed, and in some cases, nonsensical information was transcribed such as random typographical errors or repetition of a single letter such as “aaaaaaaaaa.”

Although the imaging order information was somewhat concordant in a portion of these cases, any discrepancies still could have had implications related to radiologic efficiency and effectiveness, especially for radiologists’ final interpretive report dictations. While any imperfect information could have been be edited in the radiologists’ dictation notes, this may have added an unnecessary time-consuming step. In cases where radiologists failed to note or correct auto-populated errors, an unclear or incomplete final report could have been added to both patients’ permanent medical records and referring physicians.

DISCUSSION

The authors’ Phase I data revealed the scope of errors that had occurred during the process of transcribing information from original imaging order into the RIS. 40% of sample records were discordant with their corresponding imaging order indication information, demonstrating substantial differences between what referring physicians had communicated about patients versus what information was immediately available to the radiologist interpreting the image results. Similar transcription error rates have been shown in previous studies. For example, a similar 2016 study showed the number of perfectly concordant RIS indication information increased from 232 (46.4%) to 314 (62.8%) after the implementation of a similar intervention.1 Similarly, the number of partially concordant matches decreased from 162 (32.4%) to 114 (22.8%).1

In cases of discordant information, the interpreting radiologist may need to investigate patients’ documented histories and order indications through review of the patients’ medical records and/or direct communication with the referring physician. Inadequate imaging order indication information can also potentially delay reimbursement and consume time utilized to obtain missing information.

Our QI project intervention was shown to improve significantly both the concordance and quality of transcribed RIS information. Although there was one Phase I
case in which the imaging study performed was inappropriate due to an incorrect study indication on the RIS, there were no such cases in Phase II. This finding suggests that although rare, there can be potential patient safety improvements derived from these types of QI interventions.

Project Limitations

Our smaller-scale project was conducted at a single Michigan healthcare system and we only measured outcomes during one month following the intervention. While a statistically significant improvement in transcription concordance levels was measured, the sustainability of these improvements remains unclear. A future project would be beneficial to investigate the longer-term effects of the intervention, and whether periodic repeated intervention reminders could extend the sustainability of these achieved improvements.

Although our QI intervention primarily focused on the RIS transcription process as a primary source of errors, several other potential sources were identified during our root cause analysis. Our intervention was not specifically focused on reducing cases in which the referring physician had failed to provide the radiologist an adequate amount of patient history and/or information concerning imaging order indications. This is another potential source of errors that may become increasingly common as CPOE becomes more widely implemented.\(^1\) The increased programming of electronic spell check function into RIS software programs may provide another potential source of improvement.\(^2,4\)

CONCLUSIONS

These QI project results indicate that a short educational session for radiology transcription clerks, along with placement of reminder posters, could significantly improve both the concordance and quality of transcribed information presented to interpreting radiologists on RIS documents. Future large-scale controlled samples are required to more fully examine the numerous factors likely to influence the many complex steps entailed in contemporary RIS information flow processes across our nation’s imaging departments and clinics.
DISCLOSURES

Overall study findings were presented on a poster at the 3rd Annual Michigan Summit on Quality Improvement and Patient Safety in Troy, MI on June 1, 2018, and were accepted for presentation at the Radiological Society of North America 104th Scientific Assembly and Annual Meeting in Chicago, IL, November, 2018.

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The authors declare no conflict of interest.

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2. Nancy M. Jackson, PhD, Associate Medical Researcher for data analysis and editorial assistance.
REFERENCES


TABLES AND FIGURES

Figure 1
Flow of information at Providence-Providence Park Hospital from patient presentation with image requisition to final report.

Figure 2
Root-cause analysis of authors’ transcription improvement initiative.

<table>
<thead>
<tr>
<th>Cause</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>Inaccurate Documentation On RIS</td>
</tr>
<tr>
<td>Lack of Knowledge Medical Terminology</td>
<td></td>
</tr>
<tr>
<td>Inaccurate Clinical Order</td>
<td></td>
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<tr>
<td>Lack of Grammar/Spell Check</td>
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<tr>
<td>Human Error Unaware of Importance</td>
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<tr>
<td>Lack of Reminders</td>
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<tr>
<td>Manual Data Entry</td>
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<td>People</td>
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<td>Environment</td>
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<td>Methods</td>
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</tbody>
</table>
Figure 3
Graph Demonstrating the Degree of Concordance Between Information Appearing on Original Imaging Order Compared to Information Transcribed to RIS Before and After Intervention.

Figure 4
Concordance Classification Framework for Degree of Concordance

<table>
<thead>
<tr>
<th>Concordance Classification</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concordant</td>
<td>Indication / clinical history match between clinical order and RIS.</td>
</tr>
<tr>
<td>Partially Discordant</td>
<td>Information appearing on clinical order but fails to appear on RIS.</td>
</tr>
<tr>
<td>Completely Discordant</td>
<td>Substantial information missing from the RIS.</td>
</tr>
</tbody>
</table>
**Figure 5**
Quality of Concordance

![Bar chart showing the quality of concordance with post-intervention and pre-intervention percentages for Low - incorrect indication, High, and Highest categories.]

**Figure 6**
Concordance Quality Classification Framework

<table>
<thead>
<tr>
<th>Quality of Concordance</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest</td>
<td>RIS indication contained a complete and informative patient history, and was free of any grammatical errors.</td>
</tr>
<tr>
<td>High</td>
<td>Contained grammatical errors (incorrect capitalization, unwanted abbreviation, misspellings or misused punctuation marks).</td>
</tr>
<tr>
<td>Low</td>
<td>Significant grammatical errors that added ambiguity or could easily be misunderstood.</td>
</tr>
</tbody>
</table>
Appendix 1

Intervention Email

“We will be starting a new quality initiative regarding improving the accuracy of radiology requisitions. We are asking associates to pay special attention to accurately transcribing the clinical order to the radiology requisition form. Please note that the information placed in the “reason for exam” is transferred to the dictated final report that is sent to the ordering physician. Particular attention should be paid to transcription of the order as it is written (Reason for Exam/Indication) to avoid spelling / grammatical errors. Should you notice any spelling / grammatical errors in the Cerner “reason for exam” field, please correct them prior to submitting the order in DOE or prior to completing the order in exam management. We will be collecting data to assess how much improvement we were able to achieve. Periodic reminders will be sent over this time period, and we will share the results once they are compiled. We appreciate your dedication to quality and your participation in this initiative.”

Appendix 2

Transcription Clerk Workstation Poster
Observed Clinical, Laboratory, and Echocardiographic Parameters in Takotsubo Syndrome Patients with Mortality and Decreased Ejection Fraction During Initial Hospital Admission

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ABSTRACT

HINOJOS A, VANHECKE TE, MANNING S. Observed Clinical, Laboratory, and Echocardiographic Parameters in Takotsubo Syndrome Patients with Mortality and Decreased Ejection Fraction During Initial Hospital Admission. Spartan Med. Res. J. Vol. 3, No. 2, pp. 29-47, 2018. CONTEXT: Approximately 1-2% of patients with suspected acute coronary syndrome also develop Takotsubo syndrome (TTS). This syndrome is characterized by transient systolic dysfunction of the apical and/or mid segments of the left ventricle that mimics myocardial infarction in the absence of obstructive coronary artery disease. Up to 21.8% of TTS patients develop serious complications, including death. Currently, there is no consensus on management of these patients and their complications. Thus, identifying TTS patients at higher risk for complications becomes valuable in managing their hospital course. The aim of this study was to examine the predictive significance of laboratory, echocardiographic, and clinical parameters on in-hospital mortality in a sample subgroup of TTS patients. Secondary analyses were performed on patients with reduced (i.e., <35%) ejection fractions. METHODS: This retrospective study at a community hospital identified patients from October 1, 2009 to August 31, 2015 who presented with ACS and underwent cardiac catheterization. Patients were diagnosed with TTS by features of cardiomyopathy on cardiac catheterization or echocardiogram. RESULTS: The authors analyzed data from a total of 177 eligible patients identified with TTS. The in-hospital mortality rate was 5.65%. Compared to the non-mortality subgroup, patients who suffered in-hospital mortality had significantly lower diastolic blood pressure on admission (p < 0.050), lower hemoglobin levels (p < 0.001), lower sodium (p = 0.020), higher blood urea nitrogen (p = 0.009), lower glomerular filtration rate (p = 0.016), and lower albumin levels (p < 0.001). Cox regression analyses demonstrated admission hemoglobin was significant, yielding a mortality hazard ratio of 0.760 (95% CI of 0.594-0.972, p = 0.029). CONCLUSIONS: Patients who present with TTS and hypotension, anemia, low albumin levels, elevated lactic acid and renal dysfunction were associated with higher rates of in-hospital mortality in this study’s sample population. Further, admission hemoglobin had the strongest association with death. Every unit decrease in hemoglobin increased mortality risk by 24%. Keywords: takotsubo syndrome, acute coronary syndrome, cardiomyopathy, heart failure
INTRODUCTION

Takotsubo (or “Tako-Tsubo”) syndrome (TTS) is characterized by transient systolic dysfunction of the apical and/or mid segments of the left heart ventricle mimicking myocardial infarction in the absence of obstructive coronary artery disease (CAD).\(^1,2\) Approximately 1-2% of patients with suspected acute coronary syndrome (ACS) have been found to have TTS after cardiac catheterization.\(^3\) Several studies have shown that TTS is not a benign or transient syndrome, with complications in up to 21.8% of patients.\(^4,5,6\)

Most common complications occur in the acute setting and include heart failure, tachyarrhythmias, mitral regurgitation, left ventricular (LV) outflow tract obstruction, and cardiogenic shock.\(^2,7,8,9\) Mortality rates have ranged from 1.1% to 10.2%.\(^3,5,6,8,9,10,11,12\) Although the pathogenesis of TTS is not completely understood, experts have concluded this syndrome is most likely due to a surge of catecholamines causing vascular dysfunction and direct myocardial stunning (i.e., reversible reduction of function of heart contraction after reperfusion).\(^2,13,14,15\)

Clinicians’ efforts to identify TTS patients at higher risk for complications and mortality are imperative, as traditional therapies for heart failure and cardiogenic shock have been limited and shown mixed results.\(^16\) Use of beta blockers to attenuate the catecholamine surge does not appear to improve mortality, complication rates, or prevented recurrence.\(^5,17,18\) Additionally, information regarding use of angiotensin converting enzyme inhibitors (ACEI) or aldosterone receptor blockers (ARB) is limited with potential benefits demonstrated in one retrospective study.\(^18\)

In the severely ill TTS patient, management presents unique complications such as dynamic left ventricular outflow tract (LVOT) obstruction. Use of inotropes is generally regarded as a contraindication in TTS as they can worsen the dynamic LVOT obstruction.\(^2,19\) Previous case reports have also suggested poor outcomes with use of beta agonists and vasopressors.\(^19,20\) Thus, it remains critical to identify those TTS patients at greater risk for complications since there is still little conclusive evidence for treatment available.\(^2,5\)
Purpose of Study

The specific aim of the study was to examine the significance of key laboratory, clinical, and echocardiographic parameters observed in a sample subgroup of TTS patients whose hospital course was complicated and/or may have experienced in-hospital mortality.

METHODS

This study was a retrospective chart review approved by the local institutional review board in January, 2017 and conducted at a community-based hospital in Grand Blanc, Michigan. Patient data were obtained through electronic health records pulled by the first (AH) and third (SM) authors using ICD-9 codes 410.9 (myocardial infarction) and 429.83 (Takotsubo Syndrome) from October 1, 2009 to August 31, 2015.21 The convenience sample included patients ages 18 and older who had presented as an acute myocardial infarction and underwent cardiac catheterization during their hospital stays.

Charts were reviewed independently by two separate cardiologists, and patients' TTS diagnosis was based on the Mayo Clinic Criteria and the 2016 European Society consensus statement.1,2 TTS was diagnosed in patients who had presented with ACS and demonstrated regional wall motion abnormalities without culprit atherosclerotic CAD (i.e., lesion(s) involved in an acute myocardial infarction).22,23

Each sample patient had received a cardiac catheterization to rule out acute plaque rupture, thrombus formation, coronary dissection or other pathological conditions that would explain observed patterns of temporary LV dysfunction. Patients were excluded from analyses if they had not received a cardiac catheterization, were referred for a coronary artery bypass graft, had failed a percutaneous coronary intervention, or showed no evidence of cardiomyopathy on either their cardiac catheterization or echocardiogram.

Ultimately, a total of 177 TTS patients were included for study analysis. Patients' charts were also reviewed to extract sociodemographic information, clinical data, transthoracic echocardiogram, and cardiac catheterization results. The authors used the Killip classification method to stratify sample patients' by clinical signs of heart failure.24
In this study, primary TTS was defined as patients whose primary reason for presentation was due to TTS cardiomyopathy. Secondary TTS was defined as patients who developed TTS secondary to another critical physical illness during admission.\textsuperscript{2,3}

Patients’ degree of CAD was quantified by report with no abnormal coronary arteries assigned a value of 0, minimal or mild CAD assigned a value of 1, moderate CAD or any lesion >50\% stenosis given a value of 2, severe CAD or any lesion >90\% or three or more lesions >70\% assigned a value of 3.\textsuperscript{22,23}

Echocardiogram reports were reviewed for instances of any mitral regurgitation, aortic stenosis, and aortic regurgitation. Degree of valvular dysfunction was assigned a value: none or trace was given a value of 0, mild was assigned a value of 1, moderate a value of 2, and severe a value of 3.\textsuperscript{25}

Data were analyzed by statisticians in the authors’ clinical research department using SPSS version 23.\textsuperscript{26} Dependent variables measured on a continuous scale were analyzed for significance using the independent samples t-test assuming normal distribution. Categorical data were analyzed for significance using the chi-square test for independence. Most of the results reported in this paper are presented as continuous variables expressed as a mean ± standard deviation or counts with population as appropriate.

The authors’ primary analytic outcome was to identify significant predictors of in-hospital mortality. Secondary analytic outcomes included predictors of ejection fraction (EF) < 35\% and to identify medical therapy used during patients’ hospital course to examine associations with outcomes.\textsuperscript{27}

RESULTS

A total of \(N = 177\) sample patients who met TTS criteria were identified. There were 10 (5.65\%) instances of patient mortality. Overall, 79 (44.7\%) patients demonstrated the typical apical ballooning type pattern. Primary TTS represented 155 (87.6\%) patients while secondary TTS represented 22 (12.4\%) patients. Mortality occurred in nine (5.8\%) primary TTS patients and one (4.7\%) secondary TTS patient. The most common causes of secondary TTS included gastrointestinal bleed, sepsis, and post-surgical causes. Etiologies of patient death were determined to be from ventricular tachycardia/fibrillation arrest in 40\%, pulseless electrical activity arrest 50\%, and undetermined in 10\%. 
Of the 45 (25.4%) of TTS patients identified as presenting with a ST segment elevation myocardial infarction, 18 (40%) were in the mortality subgroup versus 11 (24.5%) in the non-mortality subgroup. Medications used during the hospital course were analyzed between patients in the mortality and non-mortality subgroups. Overall, 79 (44.6%) of total sample patients had been placed on atorvastatin, 88 (49.7%) patients were placed on metoprolol tartrate, 60 (33.9%) of patients were placed on carvedilol, and 65 (36.7%) of patients were placed on Lisinopril.

Of the total sample, 33 (18.6%) patients showed moderate-to-severe mitral regurgitation (MR) on their echocardiogram. The mortality rate was 9.1% for patients with moderate-to-severe MR versus 4.9% in patients with mild or less MR. Patients with moderate-to-severe MR were significantly older (p = 0.016), had a significantly lower EF (p = 0.008), lower admission hemoglobin (p = 0.001), higher admission BUN (p = 0.004), and higher admission creatinine (p = 0.011). There were no other significant differences identified between subgroups, although left ventricular end-diastolic pressure (LVEDP) levels were somewhat higher in patients with moderate-to-severe MR, although this difference was not statistically significant (p = 0.071).

**Mortality versus Non-Mortality Subgroups**

Baseline data between the mortality and non-mortality subgroups are represented in Table 1. In the mortality subgroup, 50% of the population was male versus 22.8% in the non-mortality subgroup (p = 0.064). Apical ballooning was found in 30% of patients in the mortality subgroup versus 43.7% in the non-mortality subgroup (p = 0.496).

Table 2 demonstrates the clinical, laboratory, and echocardiographic parameters obtained between the mortality and non-mortality subgroups. As shown in this table, patients who died during hospitalization had significantly lower mean admission hemoglobin levels (p < 0.001), lower admission hematocrit levels (p= 0.001), lower admission sodium levels (p = 0.02), higher admission BUN levels (p = 0.009), lower admission glomerular filtration rate levels (p = 0.016), higher admission lactic acid (p < 0.001), and lower admission albumin levels (p <0.001).

Table 3 depicts the echocardiographic and cardiac catheterization data. Patients who died during hospitalization had a non-significant lower average EF of 36.5 (SD 16.5)% versus an average EF of 44.15 (SD 15.94)% in the non-mortality subgroup (p =
0.143). There was, however, a significantly higher degree of CAD in the mortality group versus the non-mortality group (p = 0.012).

**EF < 35% versus EF ≥ 35% Subgroups**

Further data analysis was performed comparing EF <35% versus EF ≥ 35%. (Table 4) In patients with an EF < 35% the mortality rate was 8.2%. In patients with an EF < 35% the degree of CAD was higher (p = 0.011), Killip classification was also higher (p = 0.002), and LVEDP levels were higher (p = 0.005) than in patients with an EF ≥ 35%. There were also significant differences in admission brain natriuretic peptide (BNP) lab values (p = 0.009), peak BNP (p = 0.005), and average BNP levels (p = 0.003). Other admission laboratory data in patients with an EF <35% were significantly different than in patients with an EF ≥ 35% (Table 4).

**Univariate Logistic Regression**

Variables that achieved statistical significance (i.e., p values < 0.05) from the univariate analysis were considered for inclusion in the non-parametric logistic regression model for in-hospital mortality. Variables that achieved significance from the model are found in Table 5. The Hosmer-Lemeshow goodness of fit test was used to ensure the model appropriately fit the data.28 As seen in Table 5, the p values calculated from variations in each of the admission labs of were found to be statistically significant predictors of hospitalization mortality (p values ranging from 0.028 to 0.001).

**Cox Proportional Hazards Regression**

When comparing the mortality and non-mortality subgroups, the statistically significant variables from univariate logistic regression (Table 5) were considered for analysis in a multivariate cox regression model. Ultimately, admission hemoglobin, admission creatinine, admission systolic blood pressure, and admission albumin were included in the final Cox regression model. Of these variables, admission hemoglobin was significant with a hazard ratio of 0.760 (95% CI: 0.594-0.972, p = 0.029). Thus, for each unit decrease in admission hemoglobin in TTS patients there was an associated increase in in-hospital mortality by 24%

**Multivariate Linear Regression**

A simple linear regression was calculated to predict differences between the EF <35% and EF ≥ 35% subgroups of sample patients. The statistically significant variables that were considered were taken from the univariate logistic regression results and
entered into a multivariate linear regression model. Ultimately, degree of CAD, MR, admission hemoglobin, and admission creatinine were the variables used in the model. A significant regression equation was found $F(4, 7.189) = 4.813$, $p < 0.001$, with an $R^2$ of 0.151. Although not depicted in a separate table degree of CAD ($B = -0.166$, $p = 0.024$), mitral regurgitation ($B = -0.199$, $p = 0.009$), and admission hemoglobin ($B = 0.169$, $p = 0.025$) were shown to be significant predictors of having an EF <35%.

**DISCUSSION**

TTS is a transient heart failure syndrome that can typically present with complications at similar rates to ACS patients in hospital settings.\textsuperscript{6,7,8,24} The in-hospital TTS mortality rate in this study was 5.65% which was similar to previous studies.\textsuperscript{5,6,8,9,11,12} The presence of co-morbid conditions has also been associated with poor outcomes in TTS.\textsuperscript{7,29,30,31} In their 2010 article, Brinjikji et al, reported renal impairment as a critical predictive factor related to TTS-related mortality.\textsuperscript{29} Consistent with this 2010 study, our sample patients with ESRD also had a significantly higher mortality rate. Endothelial dysfunction, oxidant stress, vascular calcifications, and inflammation from renal dysfunction also likely contribute to worse TTS patient outcomes.\textsuperscript{32}

Previous studies have demonstrated a similarly higher incidence of cancer in TTS compared to the general population.\textsuperscript{33,34} In one 2016 study, 28.5% of TTS patients were diagnosed with cancer, and the presence of cancer was found to be an independent predictor of cardiac and all-cause death in TTS.\textsuperscript{35} Although this pathologic mechanism is not well understood, it has been postulated that possessing a malignancy may enhance patients’ neurohormonal activation and the inflammatory response during the acute phase of TTS.\textsuperscript{35}

In our study, degree of CAD was significantly associated with higher degree of cardiomyopathy and in-hospital mortality. The Mayo Clinic criteria indicate that the absence of obstructive CAD is still possible with a diagnosis of TTS, and previous studies have reported non-CAD levels in up to 19% of TTS patients.\textsuperscript{5,18,36,37} Modern techniques such as fractional flow reserve and intravascular ultrasound have now provided objective measurements to evaluate potential obstructive lesions to help delineate TTS from obstructive CAD. Parodi et al (2013) stated that TTS and CAD were not mutually exclusive
and up to 10% of TTS patients may have been missed due to their exclusion of patients with documented CAD.\textsuperscript{37}

It remains especially important to recognize the presence of CAD in TTS as it is associated with poor outcomes. In Bill et al. (2017), CAD in TTS patients had significantly lower EF, higher risk of cardiogenic shock was an independent predictor of mortality when compared to non-CAD TTS patients.\textsuperscript{36} In 2016, the European Society of Cardiology recognized CAD as a risk factor for more severe heart failure during acute TTS episodes.\textsuperscript{2}

Lower hemoglobin levels place an extra demand on cardiac output and decrease blood viscosity (i.e., thickness), leading to vascular (arterial and venous) dilation, which in turn leads to increased preload.\textsuperscript{38} In a chronic anemic state, LV hypertrophy can develop and ultimately lead to LV dilation and heart failure.\textsuperscript{30} Jankoswka et al. (2014) found iron deficiency is associated with higher mortality in a 12-month follow-up of heart failure patients.\textsuperscript{32,39,40}

In our study, there was no significant difference found in BNP levels between the mortality and non-mortality sample subgroups. However, low BNP levels have been connected with favorable prognoses elsewhere.\textsuperscript{8,41} However, the correlation of BNP levels with hemodynamic parameters such as LVEDP are not as reliable in TTS.\textsuperscript{2,8,42} Our study found that patients with an EF < 35% had significantly higher elevations of BNP and higher LVEDP values.

The mechanism of TTS is not entirely understood, although it is believed to be from a surge of catecholamines causing vascular dysfunction and direct myocardial stunning. Initial surges of catecholamines appear to correlate with NT-proBNP levels and the extent of LV systolic function.\textsuperscript{43,44} Since epinephrine and norepinephrine work on the beta receptors in the ventricular myocardium, it would appear beta blockers would be the ideal treatment of this syndrome in acute TTS.\textsuperscript{13} However, patients receiving beta blockers in earlier studies have not demonstrated a significant difference in 30-day mortality cardiovascular complications, or TTS recurrence.\textsuperscript{17,18}

Inflammation also likely plays a significant role in the pathogenesis of TTS.\textsuperscript{35} Previous studies have suggested a benefit in ACEI and ARBs via the renin-angiotensin-aldosterone pathway and direct anti-inflammatory properties on the myocardium.\textsuperscript{18} The authors found no prospective studies to date examining their use in TTS.


Study Limitations

We should acknowledge several study limitations. This was a single-center study with predominantly Caucasian population so our results may not be generalizable to other ethnic groups. This study was limited by its retrospective design and the sample subgroups may have differed in unmeasured ways. None of our sample patients underwent cardiac magnetic resonance imaging to differentiate between acute infarct or myocarditis as the etiology of their cardiomyopathy.\(^2\)

Finally, due to our low number of mortality cases (n = 10) our regression model may have contained more parameters that could be justified by the data. However, we included only minimal parameters found to be significant through univariate logistic regression to reduce our risk of using an over fitted predictive model. Finally, we did not examine right ventricular involvement in these cases which has been associated with a poor prognosis in TTS.\(^{45}\)

CONCLUSIONS

In conclusion, these results demonstrate that patients who present with TTS on admission with hypotension, anemia, low albumin levels, elevated lactic acid and renal dysfunction appear to be at higher risk for in-hospital mortality. In addition, anemia may comprise one of the strongest predators of in-hospital mortality.

The lack of evidence-based therapies for this condition highlights the ongoing need for studies identifying those TTS patients at higher risk for complications. Further research is warranted to determine the most effective therapies for TTS patients so frequently already prone to health complications. Cardiology providers require further evidence from larger prospective research samples to identify optimal treatment approaches for these higher risk cardiology patients.
DISCLOSURES

The overall results of this study were presented as a poster presentation at the Statewide Campus System Poster Day, May 2017. This study was supported by the Genesys Regional Medical Center Department of Academic and Clinical Research.

The authors report no external funding source for this study.

The authors declare no conflict of interest.

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ACKNOWLEDGEMENTS

We acknowledge the support of Genesys Regional Medical Center’s Department of Clinical Research, specifically, Dr. Kimberly Barber, PhD, and Tara Knisely, MPH who contributed data cleaning and statistical analyses.

We acknowledge Dr. Heather Kirkpatrick, PhD from the Department of Education who contributed to the revision of this manuscript.
REFERENCES


Table 1
Demographics and Clinical Characteristics of Study Population Stratified By Mortality versus Non-Mortality Subgroups

<table>
<thead>
<tr>
<th></th>
<th>Mortality (n=10)</th>
<th>Non-Mortality (n=167)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (±SD)</td>
<td>Mean (±SD)</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>66.4(±16.38)</td>
<td>63.73(±13.41)</td>
<td>0.547</td>
</tr>
<tr>
<td>BMI</td>
<td>31.99 (±9.11)</td>
<td>29.29 (±7.63)</td>
<td>0.285</td>
</tr>
<tr>
<td>BSA</td>
<td>2.06(±0.34)</td>
<td>1.92(±0.32)</td>
<td>0.148</td>
</tr>
<tr>
<td>LOS</td>
<td>7.8 (±8.12)</td>
<td>5.13(±6.75)</td>
<td>0.230</td>
</tr>
<tr>
<td></td>
<td>1.8(±1.03)</td>
<td>2.3(±2.2)</td>
<td>0.476</td>
</tr>
<tr>
<td>Day of Cardiac Catheterization</td>
<td><strong>Clinical History</strong> <strong>Frequency</strong></td>
<td><strong>Frequency</strong></td>
<td><strong>p-value</strong></td>
</tr>
<tr>
<td>Male</td>
<td>50.00%</td>
<td>22.80%</td>
<td>0.064</td>
</tr>
<tr>
<td>Female</td>
<td>50.00%</td>
<td>77.20%</td>
<td>0.064</td>
</tr>
<tr>
<td>Previous PCI</td>
<td>10.00%</td>
<td>9.60%</td>
<td>0.999</td>
</tr>
<tr>
<td>Previous CABG</td>
<td>40.00%</td>
<td>2.40%</td>
<td><strong>0.001</strong></td>
</tr>
<tr>
<td>PAD</td>
<td>10.00%</td>
<td>1.80%</td>
<td>0.209</td>
</tr>
<tr>
<td>CVA</td>
<td>10.00%</td>
<td>6.00%</td>
<td>0.483</td>
</tr>
<tr>
<td>Family History of CAD</td>
<td>10.00%</td>
<td>11.40%</td>
<td>0.999</td>
</tr>
<tr>
<td>Diabetes</td>
<td>40.00%</td>
<td>20.40%</td>
<td>0.225</td>
</tr>
<tr>
<td>HTN</td>
<td>70.00%</td>
<td>65.90%</td>
<td>0.999</td>
</tr>
<tr>
<td>COPD</td>
<td>30.00%</td>
<td>16.80%</td>
<td>0.383</td>
</tr>
<tr>
<td>OSA</td>
<td>20.00%</td>
<td>7.20%</td>
<td>0.181</td>
</tr>
<tr>
<td>Smoker</td>
<td>60.00%</td>
<td>57.50%</td>
<td>0.999</td>
</tr>
<tr>
<td>History of cancer</td>
<td>50.00%</td>
<td>13.80%</td>
<td><strong>0.010</strong></td>
</tr>
<tr>
<td>History of heart failure</td>
<td>20.00%</td>
<td>8.40%</td>
<td>0.225</td>
</tr>
<tr>
<td>ESRD</td>
<td>40.00%</td>
<td>13.20%</td>
<td><strong>0.042</strong></td>
</tr>
<tr>
<td>Depression</td>
<td>20.00%</td>
<td>32.30%</td>
<td>0.507</td>
</tr>
</tbody>
</table>

* Significant p values appear in bold font.

** Body mass index (BMI), Body surface area (BSA), Length of stay (LOS), Percutaneous coronary intervention (PCI), Coronary artery bypass graft (CABG), Peripheral artery disease (PAD), Cerebrovascular accident (CVA), Coronary artery disease (CAD), Hypertension (HTN), Chronic obstructive pulmonary disease (COPD), Obstructive sleep apnea (OSA), End-stage renal disease (ESRD).
# Table 2

## Cardiac Biomarkers, Admission Vitals and Laboratory Data for the TTS Subgroups

<table>
<thead>
<tr>
<th>Cardiac Biomarkers</th>
<th>Mortality (n=10) Mean (±SD)</th>
<th>Non-Mortality (n=167) Mean (±SD)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Troponin (ng/ml)</td>
<td>0.43(±0.44)</td>
<td>2.28(±6.74)</td>
<td>0.440</td>
</tr>
<tr>
<td>Peak Troponin (ng/ml)</td>
<td>0.45(±0.44)</td>
<td>3.5(±11.05)</td>
<td>0.410</td>
</tr>
<tr>
<td>Admission Troponin (ng/ml)</td>
<td>0.35(±0.46)</td>
<td>0.76(±1.76)</td>
<td>0.490</td>
</tr>
<tr>
<td>Average BNP (pg/ml)</td>
<td>2184.38(±3406.08)</td>
<td>3379.62(±8204.52)</td>
<td>0.945</td>
</tr>
<tr>
<td>Peak BNP (pg/ml)</td>
<td>3164.31(±3444.76)</td>
<td>4335.62(±10860.48)</td>
<td>0.580</td>
</tr>
<tr>
<td>Admission BNP (pg/ml)</td>
<td>2095.37(±3284.15)</td>
<td>3427.63(±8389.59)</td>
<td>0.658</td>
</tr>
</tbody>
</table>

## Admission Vitals

| Admission SBP (mmHg)         | 119.9(±47.51)               | 143.06(±35.87)                   | 0.053   |
| Admission DBP (mmHg)         | 58.5(±27.09)                | 80.66(±22.23)                    | 0.003   |
| Admission HR (bpm)           | 86.00(±19.56)               | 88.94(±24.99)                    | 0.716   |

## Laboratory Data

| Cortisol level (µg/ml)       | 36.73(18.82)                | 25.64(±16.38)                    | 0.332   |
| TSH (uIU/ml)                 | 1.63(±0.44)                 | 2.35(±2.91)                      | 0.671   |
| Free Thyroxine (ng/dl)       | 0.79(±0.07)                 | 1.09(±0.43)                      | 0.333   |
| HDL level (mg/dl)            | 46.42(±18.34)               | 45.64(±14.81)                    | 0.901   |
| LDL level (mg/dl)            | 52.41(±17.81)               | 87.06(±34.34)                    | 0.016   |

## Admission Laboratory Data

| Admission hemoglobin (g/dl)  | 11.31(±2.08)                | 13.59(±1.87)                     | 0.001   |
| Admission sodium (mmol/L)    | 135.10(±3.93)               | 137.61(±3.24)                    | 0.020   |
| Admission BUN (mg/dl)        | 28.60(±16.59)               | 19.17(±10.51)                    | 0.009   |
| Admission creatinine (mg/dl) | 1.65(±0.91)                 | 1.07(±1.09)                      | 0.101   |
| Admission GFR                | 49.80(±28.44)               | 71.21(±27.04)                    | 0.016   |
| Admission lactic acid (mmol/L) | 7.59(±5.18)               | 2.39(±2.11)                      | 0.001   |
| Admission albumin (g/dl)     | 3.22(±0.46)                 | 3.89(±0.49)                      | 0.001   |

## Average Laboratory Data

| Average hemoglobin (g/dl)    | 10.45(±1.89)                | 12.52(±1.61)                     | 0.001   |
| Average sodium (mmol/L)      | 135.50(±4.48)               | 138.55(±2.60)                    | 0.001   |
| Average BUN (mg/dl)          | 37.65(±19.59)               | 17.69(±7.62)                     | 0.001   |
| Average creatinine (mg/dl)   | 2.01(±1.20)                 | 0.97(±1.06)                      | 0.003   |
| Average GFR                  | 54.50(±58.15)               | 80.60(±28.03)                    | 0.009   |
| Average lactic acid (mmol/L) | 5.77(±0.87)                 | 1.84(±0.93)                      | 0.001   |
| Average albumin (g/dl)       | 2.86(±0.59)                 | 3.64(±0.55)                      | 0.001   |

* Significant p values appear in **bold** font

** Brain natriuretic peptide (BNP), Systolic blood pressure (SBP), Diastolic blood pressure (DBP), Heart rate (HR), Millimeters of mercury (mmHg), Beats per minute (bpm), Thyroid stimulating hormone (TSH), High density lipoprotein (HDL), Low density lipoprotein (LDL), Blood urea nitrogen (BUN), Glomerular filtration rate (GFR)
Table 3
Echocardiographic Data and Cardiac Catheterization Data
for the Mortality and Non-Mortality Subgroups

<table>
<thead>
<tr>
<th>Echocardiographic Data</th>
<th>Mortality (n=10)</th>
<th>Non-Mortality (n=167)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (±SD)</td>
<td>Mean (±SD)</td>
<td></td>
</tr>
<tr>
<td>Ejection Fraction (%)</td>
<td>36.5(±16.5)</td>
<td>44.15(±15.94)</td>
<td>0.143</td>
</tr>
<tr>
<td>Diastolic Dysfunction</td>
<td>1.0(±1.05)</td>
<td>0.73(±0.82)</td>
<td>0.452</td>
</tr>
<tr>
<td>Aortic stenosis****</td>
<td>0.30(±0.95)</td>
<td>.13(±0.54)</td>
<td>0.347</td>
</tr>
<tr>
<td>Aortic regurgitation****</td>
<td>0.2(±0.54)</td>
<td>0.13(±0.39)</td>
<td>0.580</td>
</tr>
<tr>
<td>Mitral regurgitation****</td>
<td>1.0(±1.05)</td>
<td>0.73(±0.82)</td>
<td>0.326</td>
</tr>
<tr>
<td>RVSP (mmHg)</td>
<td>37.04(±8.83)</td>
<td>36.55(±11.66)</td>
<td>0.907</td>
</tr>
<tr>
<td>Cardiac Catheterization Data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LVEDP (mmHg)</td>
<td>24.5(±9.99)</td>
<td>19.6(±6.54)</td>
<td>0.082</td>
</tr>
<tr>
<td>Degree of CAD*****</td>
<td>2.67(±1.32)</td>
<td>1.93(±0.83)</td>
<td><strong>0.012</strong></td>
</tr>
</tbody>
</table>

* Significant p values appear in **bold** font.

**** Right ventricular systolic pressure (RVSP), left ventricular end-diastolic pressure (LVEDP), Coronary artery disease (CAD).
### Table 4

**Clinical Variables, Echocardiographic Data, Cardiac Biomarkers, Admission Laboratory Data, Laboratory Data for the Sub-Group Analysis**

**EF < 35% versus EF ≥ 35%**

<table>
<thead>
<tr>
<th>Variable</th>
<th>EF &lt; 35% (n = 49)</th>
<th>EF ≥ 35% (n = 128)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOS (days)</td>
<td>7.41 (±5.36)</td>
<td>4.46 (±7.17)</td>
<td>0.010</td>
</tr>
<tr>
<td>LVEDP (mmHg)</td>
<td>22.26 (±7.34)</td>
<td>18.88 (±6.28)</td>
<td>0.005</td>
</tr>
<tr>
<td>Degree of CAD</td>
<td>2.24 (±1.00)</td>
<td>1.86 (±0.79)</td>
<td>0.011</td>
</tr>
<tr>
<td>Killip classification</td>
<td>2.31 (±1.19)</td>
<td>1.72 (±1.06)</td>
<td>0.002</td>
</tr>
</tbody>
</table>

**Echocardiographic Data**

<table>
<thead>
<tr>
<th>Variable</th>
<th>EF &lt; 35% (n = 49)</th>
<th>EF ≥ 35% (n = 128)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diastolic Dysfunction</td>
<td>0.91 (±1.08)</td>
<td>0.76 (±0.85)</td>
<td>0.505</td>
</tr>
<tr>
<td>Mitral regurgitation</td>
<td>1.13 (±0.95)</td>
<td>0.61 (±0.75)</td>
<td>0.001</td>
</tr>
<tr>
<td>RVSP (mmHg)</td>
<td>40.48 (±11.72)</td>
<td>34.99 (±11.05)</td>
<td>0.012</td>
</tr>
</tbody>
</table>

**Cardiac Biomarkers**

<table>
<thead>
<tr>
<th>Variable</th>
<th>EF &lt; 35% (n = 49)</th>
<th>EF ≥ 35% (n = 128)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Troponin (ng/ml)</td>
<td>2.93 (±8.88)</td>
<td>1.91 (±5.48)</td>
<td>0.371</td>
</tr>
<tr>
<td>Admission Troponin (ng/ml)</td>
<td>0.93 (±2.47)</td>
<td>0.67 (±1.33)</td>
<td>0.371</td>
</tr>
<tr>
<td>Average BNP (pg/ml)</td>
<td>6289.49 (±11303.98)</td>
<td>1357.91 (±3145.84)</td>
<td>0.003</td>
</tr>
<tr>
<td>Peak BNP (pg/ml)</td>
<td>7783.81 (±14790.68)</td>
<td>1703.02 (±4736.49)</td>
<td>0.005</td>
</tr>
<tr>
<td>Admission BNP (pg/ml)</td>
<td>5954.38 (±10970.68)</td>
<td>1534.04 (±4645.63)</td>
<td>0.009</td>
</tr>
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</table>

**Admission Laboratory Data**

<table>
<thead>
<tr>
<th>Variable</th>
<th>EF &lt; 35% (n = 49)</th>
<th>EF ≥ 35% (n = 128)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admission hemoglobin (g/dl)</td>
<td>12.61 (±2.33)</td>
<td>13.79 (±1.67)</td>
<td>0.001</td>
</tr>
<tr>
<td>Admission sodium (mmol/L)</td>
<td>136.59 (±4.36)</td>
<td>137.81 (±2.76)</td>
<td>0.029</td>
</tr>
<tr>
<td>Admission BUN (mg/dl)</td>
<td>22.61 (±14.08)</td>
<td>18.56 (±9.55)</td>
<td>0.030</td>
</tr>
<tr>
<td>Admission creatinine (mg/dl)</td>
<td>1.42 (±1.92)</td>
<td>0.98 (±0.43)</td>
<td>0.014</td>
</tr>
<tr>
<td>Admission GFR</td>
<td>63.84 (±29.71)</td>
<td>72.37 (±26.33)</td>
<td>0.065</td>
</tr>
<tr>
<td>Admission albumin (g/dl)</td>
<td>3.71 (±0.51)</td>
<td>3.91 (±0.49)</td>
<td>0.022</td>
</tr>
</tbody>
</table>

**Laboratory Data**

<table>
<thead>
<tr>
<th>Variable</th>
<th>EF &lt; 35% (n = 49)</th>
<th>EF ≥ 35% (n = 128)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average hemoglobin (g/dl)</td>
<td>11.59 (±1.91)</td>
<td>12.71 (±1.49)</td>
<td>0.001</td>
</tr>
<tr>
<td>Average sodium (mmol/L)</td>
<td>137.79 (±3.65)</td>
<td>138.60 (±2.40)</td>
<td>0.088</td>
</tr>
<tr>
<td>Average BUN (mg/dl)</td>
<td>22.04 (±13.01)</td>
<td>17.59 (±7.95)</td>
<td>0.006</td>
</tr>
<tr>
<td>Average creatinine (mg/dl)</td>
<td>1.34 (±1.92)</td>
<td>0.91 (±0.47)</td>
<td>0.020</td>
</tr>
<tr>
<td>Average albumin (g/dl)</td>
<td>3.31 (±0.58)</td>
<td>3.71 (±0.54)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

* Significant p values appear in **bold** font.

** Length of stay (LOS), Left ventricular end diastolic pressure (LVEDP), Coronary artery disease (CAD), left ventricular outflow tract (LVOT), Right ventricular systolic pressure (RVSP), Brain natriuretic peptide (BNP), Glomerular filtration rate (GFR), Blood urea nitrogen (BUN).
### Table 5
Univariate Logistic Regression for the Prediction of Patients with Mortality in Takotsubo Syndrome

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient (B)</th>
<th>Wald X²</th>
<th>Sig.*</th>
<th>Odds Ratio</th>
<th>95.0% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admission Diastolic BP</td>
<td>-0.053</td>
<td>0.018</td>
<td>0.003</td>
<td>0.948</td>
<td>0.915 - 0.983</td>
</tr>
<tr>
<td>Admission Hemoglobin</td>
<td>-0.48</td>
<td>10.011</td>
<td>0.002</td>
<td>0.619</td>
<td>0.46 - 0.833</td>
</tr>
<tr>
<td>Admission Hematocrit</td>
<td>-0.147</td>
<td>8.272</td>
<td>0.004</td>
<td>0.863</td>
<td>0.781 - 0.954</td>
</tr>
<tr>
<td>Admission Sodium</td>
<td>-0.174</td>
<td>4.937</td>
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<td>0.001</td>
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* Significant p values appear in **bold** font.
Original Contribution

Topical Tranexamic Acid Reduces Postoperative Blood Loss in Primary Total Hip and Knee Arthroplasty

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ABSTRACT

CARUTHERS CM, BRAZIER BG, BLACKMER MJ, RAEHTZ S, ETIENNE G. Topical Tranexamic Acid Reduces Postoperative Blood Loss in Primary Total Hip and Knee Arthroplasty. Spartan Med. Res. J. Vol. 3, No. 2, pp. 48-62, 2018. CONTEXT: The purpose of this study was to assess the effectiveness of topical pre-closure application of tranexamic acid (TXA) to reduce postoperative blood loss and blood transfusion rates in primary total hip and knee arthroplasty (THA and TKA) in a private, high-volume orthopedic specialty hospital setting. METHODS: This was a retrospective study examining 140 consecutive patients undergoing primary hip or knee arthroplasty at the sample setting by a single surgeon. The first 70 patients did not receive topical TXA (2 gm./20ml.), the final 70 did receive topical TXA. We compared the postoperative hemoglobin levels of both sample subgroups at postoperative days 1, 2, and 3. RESULTS: Overall, the postoperative hemoglobin levels were significantly higher in the TXA group on postoperative days 1, 2, and 3 (p < 0.05). When patients who underwent THA (n = 70) were investigated separately, the hemoglobin levels were significantly higher on postoperative days 1, 2, and 3 in the group that received TXA. In the TKA group (n = 70), there was not a significantly higher hemoglobin level in patients who received TXA. There were no blood transfusions in the entire study cohort. Possibly due to the more restrictive transfusion criteria employed in this study, the total estimated prospective cost savings from use of TXA was calculated at about $116 per patient. CONCLUSIONS: Based on these results from a high volume orthopedic specialty hospital, pre-closure topical TXA application may prove effective in reducing postoperative blood loss for some patients but have a relatively small impact on cost outcomes. Keywords: topical tranexamic acid, total knee arthroplasty, total hip arthroplasty, allogenic blood transfusion
INTRODUCTION

The application of tranexamic acid (TXA) has become an emerging therapy proposed in the joint arthroplasty literature as surgeons have become increasingly aware of complications relating to allogenic blood transfusion (i.e., transfusion of blood from a donor).¹,² These include: transmission of infectious agents, postoperative infections and wound complications, transfusion reactions, intravascular coagulation, volume overload, renal failure, and short-term mortality.¹-⁶ Furthermore, at a time when cost-effectiveness continues to be increasingly scrutinized, reducing blood transfusion and its associated expenses (e.g., laboratory acquisition/processing/storage costs, length of hospital stay, managing postoperative complications) continues to be an important topic.¹,⁵

Traditionally, techniques for reducing blood loss in joint arthroplasty have included controlled hypotensive anesthesia, tourniquets with pressure-controlled pumps, autologous blood transfusion (i.e. collection and reinfusion of the patient’s own red blood cells), and local injections.³,⁵ Transfusion rates in primary hip and knee arthroplasty, however, continue to be elevated with some studies showing transfusion rates as high as 16 to 37%.⁷ Thus, efforts to reduce the use of allogenic blood transfusion have become a focus in orthopedics and the use of TXA has substantially increased over the last decade.¹,²

TXA is a synthetic derivative of the amino acid lysine that carries out its effects through an antifibrinolytic pathway.⁸-¹⁰ TXA stabilizes formed clots and prevents the degradation of fibrin by reversibly inhibiting the lysine-binding site on plasminogen. This impairs plasminogen’s linkage with fibrin to become plasmin, which normally creates a fibrinolytic effect and dissolves clots. TXA was introduced in cardiac surgery more than 40 years ago, and is now increasingly used to control bleeding in cardiothoracic, trauma, obstetric and gynecological, gastrointestinal, urologic, and ear, nose, and throat surgeries.⁸-¹⁰

Due to the antifibrinolytic mechanism of action of TXA, there have been concerns expressed in the literature about the thrombogenic side effects of its administration, particularly with intravenous (IV) use of the drug.¹⁰-¹¹ This continues to be the case even though there have been several meta-analyses completed showing no significant
difference in the numbers of deep vein thrombosis (DVT) or pulmonary embolus (PE) events in patients receiving IV TXA.\textsuperscript{10}

In fact, some studies have suggested fewer thromboembolic events with the use of TXA.\textsuperscript{11} Regardless, these theoretical risks have moved many surgeons away from the use of IV TXA.\textsuperscript{1,2} Regardless of the mixed results obtained to date, topical application of higher concentration TXA may be an alternative that provides similar benefits without concerns of possible systemic side effects.

**Purpose of Study**

The aim of this study was to examine whether the pre-closure topical application of TXA helped to reduce postoperative blood loss and to evaluate whether topical TXA reduced the need for blood transfusion in a high-volume center. Additionally, a secondary goal of this study was to examine the validity of the debate on the effectiveness of topical TXA. A final goal of the study was to assess whether TXA is cost effective in primary total knee (TKA) or total hip arthroplasty (THA).

**METHODS**

Before data collection, the Michigan State University institutional review board certified the study as exempt from full review. A retrospective analysis was performed on 140 consecutive de-identified joint arthroplasty patients meeting the inclusion criteria. Inclusion criteria included all patients undergoing primary THA or TKA at a single institution by a single surgeon from April 2015 to September 2015. This institution was an orthopedic surgery specialty hospital where in 2017 there were 426 THA, 752 TKA and 152 unicompartmental (i.e., “partial”) knee arthroplasties completed for a total of 1,330 joint replacement surgeries.

Preoperative hemoglobin levels as well as postoperative hemoglobin levels for the first three postoperative days were required for inclusion into the study. Patient demographic data collected included age and BMI were also collected to assess any potential subgroup differences. The initial 70 analytic sample patients had not received topical TXA and the final 70 patients did receive topical TXA at the conclusion of surgery.
Operative technique

All TKA surgeries were performed by a single surgeon. The surgeries involved either spinal or general anesthesia as well as administration of standard preoperative antibiotics. A midline incision with a medial parapatellar arthrotomy was used. A tourniquet was utilized in all cases and bleeding was managed with electrocautery. Implants included a cruciate retaining, fixed bearing total knee system. A standard Hemovac drain was placed prior to arthrotomy closure but not compressed until two hours postoperatively to remove any fluid or blood build-up in the joint. The group receiving TXA had it administered topically prior to closure of the arthrotomy at a standard dose of 2g/20mL.8

The same surgeon performed all of the THA surgeries with spinal or general anesthesia used for all surgeries. All THA procedures were completed through a direct anterior approach with use of an orthopedic table and press fit components were used for all patients. A Hemovac drain was placed at the conclusion of the case but not compressed until two hours postoperatively. In the group receiving TXA, it was topically administered prior to closure of the hip capsule using the same standard dose of 2g/20mL.8

Postoperatively, hemoglobin and hematocrit levels were drawn for three consecutive days. All patients received standard physical and occupational therapy protocols and received 24 hours of postoperative antibiotics. Enoxaparin and sequential compression devices were used for DVT prophylaxis. Discharge was typically on postoperative day 3. Preoperative and postoperative hemoglobin levels as well as patient demographics were retrieved retrospectively.

Statistical analyses were completed by the 2nd (BGB) and 4th author (SR) using GraphPad Prism version 7.00 for windows analytic software.12 All reported values represent the mean +/- the standard error of the mean (SEM). Gender comparison of hemoglobin levels were performed using one-way ANOVA with Fisher’s post-hoc test for paired subgroups. Cohorts were compared using two-way ANOVA with repeated measures using the Sidak multiple comparisons post-hoc test to examine differences between TXA treatments.
A two-way ANOVA was utilized to examine the influence that two different variables independently exerted on the single selected continuous outcome (i.e., postoperative hemoglobin levels). Additionally, Pearson’s correlation analyses were performed. A cut-off point of a p-value less than 0.05 was observed for all analytic procedures to indicate statistical significance.

RESULTS

During the study, there were a total of 140 joint arthroplasty cases reviewed. There were no statistically significant differences found in age or BMI between patient subgroups that received TXA versus those that did not. (Table 1) This is important to note since a difference in these measures could have skewed subgroup outcome differences. Furthermore, using Pearson correlation analysis, there were no significant correlations found between age or BMI with postoperative hemoglobin levels (data not shown). While there was a statistically significant difference in hemoglobin levels between genders at each point measured, there was no difference in the percentage change of hemoglobin between males and females when compared to preoperative levels. Due to this, the analytic authors proceeded to group the genders for further analysis.

The results of the 70 patients who underwent THA in the study are shown in Figure 1. Of these patients, 34 (49%) received topical TXA and 36 (51%) did not receive topical TXA. The mean hemoglobin of the patients who received TXA was 14.04 ± 1.12 g/dL preoperatively and 10.93 ± 0.79, 10.57 ± 0.72, and 10.72 ± 0.87 at postoperative days 1, 2, and 3 respectively. The mean hemoglobin of the group that did not receive TXA was 13.50 ± 1.22 g/dL preoperatively and 10.73 ± 1.03, 10.44 ± 1.22, and 10.36 ± 1.21 at postoperative days 1, 2, and 3 respectively. Statistical analysis demonstrated significantly higher hemoglobin levels in the group receiving topical TXA at postoperative days 1, 2, and 3 (p < 0.05) with no significant difference in preoperative hemoglobin levels.

Data from the 70 patients who underwent TKA are shown in Figure 2. Of the 70 patients, 36 (51%) received topical TXA and 34 (49%) did not receive topical TXA. The mean hemoglobin of the patients who did receive TXA was 13.34 ± 1.03 g/dL preoperatively and 10.73 ± 1.03, 10.44 ± 1.22, and 10.36 ± 1.21 at postoperative days 1, 2, and 3 respectively. The mean hemoglobin of patients who did not receive TXA was
13.50 ± 1.22 g/dL preoperatively and 10.36 ± 1.34, 9.91 ± 1.46, and 9.70 ± 1.51 at postoperative days 1, 2, and 3 respectively. There was not a statistically significant difference between hemoglobin levels at postoperative days 1 through 3 and there was no significant difference in preoperative hemoglobin levels.

Figure 3 shows the analytic results of all patients (i.e., combined THA and TKA) comparing hemoglobin levels between those who did receive topical TXA with those who did not receive topical TXA. The mean hemoglobin of those patients who received TXA was 13.69 ± 1.12 g/dL preoperatively and 10.83 ± 0.92, 10.50 ± 1.01, and 10.53 ± 1.07 at postoperative days 1, 2, and 3 respectively. The mean hemoglobin of those patients who did not receive TXA was 13.66 ± 1.15 g/dL preoperatively and 10.31 ± 1.22, 9.89 ± 1.29, and 9.78 ± 1.41 at postoperative days 1, 2, and 3 respectively. Similar to the THA only group, the results of statistical analyses demonstrated significantly higher hemoglobin levels in the patients who received topical TXA at postoperative days 1 through 3 (p < 0.05).

There were only six (4.3%) sample patients in which postoperative hemoglobin levels ever dropped below 8 g/dL and none of them required blood transfusion. Of these patients, four (67%) were in the THA subgroup and two (33%) in the TKA subgroup. None of these patients whose hemoglobin levels dropped below 8 g/dL had received topical TXA.

**DISCUSSION**

These results demonstrate that topical TXA can be effective at reducing postoperative decreases in hemoglobin levels after either primary THA or TKA. Overall, postoperative hemoglobin levels were significantly higher in the cohort of patients that received TXA compared to those that did not at postoperative days 1, 2, and 3. The effect of TXA appears to have been more pronounced in the THA subgroup, as the postoperative hemoglobin was significantly higher at all three postoperative days compared to the TKA subgroup, which did not have statistically significantly higher hemoglobin levels on any of the postoperative days.

In other settings, TXA has already been shown to be effective both topically and intravenously in multiple studies for both THA and TKA for reducing perioperative blood
loss.\textsuperscript{1,9,13-18} In this study, the effect of topical TXA appears to be more pronounced in the THA subgroup. The reason for this is unclear but may be due to increased operative time, differences in intravenous fluid hydration, or the more extensive dissection generally required for the THA procedure.

Pursuant to institutional criteria, there were no patients in this study who required an allogenic blood transfusion. This 0\% rate is significantly lower than the literature reported rates for blood transfusion for primary THA and TKA, which have been listed anywhere from 11 to 67\%.\textsuperscript{18,19,22} Our intuitional transfusion guidelines matched the American Association of Blood Banks recommendations which comprised a restrictive transfusion strategy for patients with hemoglobin less than or equal to 8 g/dL and associated symptoms consistent with blood loss anemia.\textsuperscript{2}

Other studies have also advocated for more restrictive transfusion criteria, finding no benefit for transfusion in patients with a hemoglobin level >8 g/dL regardless of cardiovascular risk.\textsuperscript{20,22,23} The authors’ adherence to the less stringent guidelines in this study would likely have led to transfusion of six patients in which the hemoglobin levels dropped below 8 g/dL but had not received topical TXA.

In 2013, Tuttle et al. performed a cost-benefit analysis of topical TXA in primary THA and TKA.\textsuperscript{24} In the study, they estimated the cost for transfusing one unit of packed red blood cells (PRBC) to be $787 and the cost of 1 g of TXA to be $58. They found a reduced transfusion rate from 17.5\% to 5.5\% after use of topical TXA and number of units transfused per patient dropped from 0.286 to 0.106 leading to a cost savings of $8373 per 100 patients treated or $83.73 per patient. Of note, the transfusion criteria observed in this 2013 study was a hemoglobin level of less than 8 g/dL or symptomatic anemia.\textsuperscript{24}

If a similar cost-benefit analysis was performed using our study data, using the same transfusion criteria of hemoglobin < 8 g/dL (which would have led to a transfusion of six patients in the cohort who had not received topical TXA). This means that six (8.57\%) out of 70 patients who had not received TXA would have been transfused and 0 (0\%) of 70 non-TXA patients would have been transfused. Cost estimates based on a per patient transfusion of two units PRBC and with the reduction of 8.57\% of allogenic units transfused ((787.37*8.57) x 2 units PRBC) totals $13,489.18.
Factoring in the cost of TXA and subtracting 2 grams used per patient for every 100 patients ($13,489.18 - $11,600.00), the cost savings would be $1,889.00 (per 100 patients treated) or $18.89 per patient. Assuming a transfusion of 1 unit of PRBC per patient, ((787.37*8.57) - 11600), the cost savings would have been $4,852.00 (per 100 patients treated) or $48.52 per patient. However, the use of the more restrictive transfusion criteria observed during this study period led to no patients being transfused and thus the total cost savings was $11,600.00 per 100 patients or $116 per patient.

These results suggest that the use of TXA may not be as cost beneficial if a restrictive blood transfusion criteria is used. If less stringent transfusion criteria had been utilized, however, the cost of topical TXA would partially offset secondary transfusion costs. Furthermore, a greater benefit of TXA use may be realized at institutions that have higher transfusion rates. The main goal from TXA use for most surgeons is to ultimately decrease the number of blood transfusions. However, the results of this study indicate that topical TXA applications had not reduced the number of transfusion events for this single high-volume arthroplasty surgeon.

**Study Limitations**

We acknowledge several limitations to this study. First, all surgeries were performed at a high-volume orthopedic specialty hospital by one fellowship-trained arthroplasty surgeon. Because of this, there were shorter operative times and lower blood loss than would be expected for a lower volume surgeon and center and may account for the zero-transfusion rate that we found. This fact could limit the generalizability of our results to other settings. These results may not be representative of the significant number of TKAs performed at lower-volume hospitals typically associated with higher transfusion rates. However, the use of TXA may actually still be more beneficial for lower-volume orthopedic surgeons with longer operative times and higher blood loss.

Second, the study sample was comprised of a relatively smaller number of THA and TKA patients in Pennsylvania. In addition, there is the possibility for numerous unmeasured confounding influences on these results (e.g., variability in IV fluid administration and drain output). Finally, these were retrospective analyses subject to possible inherent weaknesses compared to prospective, randomized, and blinded data sources.
CONCLUSIONS

Based on these results, pre-closure topical TXA application may prove effective in reducing postoperative blood loss but have less impact on transfusion rates or cost outcomes. Standardized doses of topical TXA were particularly shown to be effective in reducing perioperative blood loss in THA surgeries. These findings, however, failed to indicate any sizable cost savings derived from TXA use. Future studies are needed to analyze outcomes associated with topical TXA in varied orthopedic contexts such as high versus low volume joint arthroplasty settings, TXA use in revision cases, bilateral TKA procedures, etc.

The authors report no external funding source for this study

The authors declare no conflict of interest

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12. GraphPad Prism version 7.00 for windows software. LaJolla, CA www.graphpad.com


Topical Tranexamic Acid Reduces Postoperative Blood Loss in Primary Total Hip and Knee Arthroplasty

TABLES AND FIGURES

Figure 1
Total Hip Arthroplasty Cohort. Mean Hemoglobin Levels ± SEM (G/DL) and Demographics of Patients Who Did (+) or Did Not (-) Receive Topical TXA. This Was Evaluated Pre-Operatively, On Post-Operative Day 1 (POD 1), POD 2, and POD 3. P-Value Considered Statistically Significant if < 0.05.
Figure 2
Total Knee Arthroplasty Cohort. Mean Hemoglobin Levels ± SEM (G/dL) and Demographics of Patients Who Did (+) or Did Not (-) Receive Topical TXA. This Was Evaluated Pre-Operatively, On Post-Operative Day 1 (POD 1), POD 2, and POD 3. P-Value Considered Statistically Significant if < 0.05.

TKA Only

Hemoglobin (g/dL)

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C Caruthers et al.
Figure 3
All patients (THA + TKA). Mean Hemoglobin Levels ± SEM (g/dL) and Demographics of Patients Who Did (+) or Did Not (-) Receive Topical TXA. This Was Evaluated Pre-Operatively, On Post-Operative Day 1 (POD 1), POD 2, and POD 3. P-Value Considered Statistically Significant if < 0.05.

TKA and THA Combined

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p > 0.9999
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Table 1
Patient Demographics between Groups. Values Represent the Mean +/- SEM. There Was No Statistical Significance between Groups in Regards to Demographics.

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THA = Total Hip Arthroplasty
TKA = Total Knee Arthroplasty
Delivering the AAMC “Teaching for Quality” Program through a Community-Based GME Collaborative: Lessons Learned to Date

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ABSTRACT

CHURCH B, CORSER W, ROHRER J, HORTOS K, HARRISON A. Delivering the AAMC “Teaching for Quality” Program through a Community-Based GME Collaborative: Lessons Learned to Date. Spartan Med. Res. J. Vol. 3, No. 2, pp. 63-74, 2018. CONTEXT: To address scholarly activity (SA) accreditation standards, the Michigan State University’s College of Osteopathic Medicine Statewide Campus System has offered the Association of American Medical Colleges’ (AAMC) Teaching for Quality Program for two cohorts of community-based faculty. The purpose of this paper was to describe the design and delivery of the customized program, the authors’ initial lessons learned, and their plans for further evaluation and dissemination. METHODS: The authors customized the program to overcome the barriers typically faced by community-based program faculty learners through a graduate medical education (GME) consortium model. This was the first time this program was delivered in this manner. RESULTS: The authors’ initial cohort of 19 learners successfully developed 15 projects, with two pairs of learners collaborating on projects. The second cohort of 15 learners developed 11 projects, with one pair of learners collaborating. The authors present a series of principles for community-based GME leaders striving to develop SA projects in their respective GME environments. CONCLUSIONS: The “consortium advantage” derived from entities such as the SCS may prove integral to efficiently coordinating SA project resources and knowledge across diverse GME systems. Keywords: scholarly activity, quality improvement, patient safety, graduate medical education

INTRODUCTION

During recent years, graduate medical education (GME) in the U.S. has continued to experience substantial changes, most notably moving to a single accreditation system. Under this new system, graduates of both allopathic and osteopathic medical schools complete residency and/or fellowship training in programs accredited by the Accreditation
Council for Graduate Medical Education (ACGME). All resident physicians and GME faculty are required to meet common standards and requirements as outlined in the ACMGE’s Next Accreditation System (NAS).

Many community-based residency programs have experienced considerable challenges meeting these new ACGME requirements, particularly those related to increased faculty and residents scholarly activity (SA) project expectations and compliance with the Clinical Learning Environment Review (CLER). Community-based GME officials may be especially challenged meeting accreditation standards due to barriers including: 1) lack of time, 2) inadequate training and experience, and 3) lack of resources and knowledge required to complete SA projects and disseminate results.

To address SA accreditation standards, the Statewide Campus System (SCS) at Michigan State University’s College of Osteopathic Medicine (MSUCOM) has offered the Association of American Medical Colleges’ (AAMC) Teaching for Quality (Te4Q) Program for two cohorts of community-based faculty. SCS customized the program to overcome the barriers typically faced by community-based program faculty by training cohorts of learners through a consortium model. This was the first time this program had been delivered in this manner.

The purpose of this paper is to describe the design and delivery of the program, the authors’ initial lessons learned, and their plans for further evaluation and dissemination. The authors will conclude with a series of general principles for GME leaders striving to develop projects at their respective SA environments.

METHODS

Setting

The SCS was founded in 1989 as a statewide consortium to improve the quality of Michigan osteopathic GME. Today, the SCS represents 37 community-based hospitals, 7 federally qualified health centers, and 176 residency programs accredited by the ACGME and/or the American Osteopathic Association (AOA). The consortium is charged with serving the GME needs of residency designated institutional officers, directors of medical education, program directors and over 1,900 residents and fellows.
**Program Planning**

The Te4Q\(^{14}\) program is a multi-faceted faculty development program designed to train faculty learners to teach effective quality improvement and patient safety (QIPS) principles to medical students, residents, and other clinicians. The AAMC initially (2013) designed the program to train up to 30 faculty in a single institution over a 15-to-18 month timeframe to:

- Identify a gap in their QIPS education;
- Design a feasible QIPS project to address that gap;
- Conduct the project and assess its impact; and
- Produce a SA poster, article, or presentation concerning their project results.

This overall training program sequence is illustrated in Figure 1.

During the original planning process, the SCS Office of Faculty Development recognized that program implementation through a consortium would present unique challenges (e.g. more complex cross-system communications, GME program variations, etc.) for both SCS “coaches” and faculty learners. Additionally, the authors recognized that the program would need to be customized to overcome the barriers typically faced by community-based clinicians conducting SA projects. Therefore, they proposed the following modifications to the delivery of the program to central AAMC office faculty who were especially supportive:

**Barrier #1: Lack of time**

**Program resource identification.** The authors customized the Te4Q\(^{14}\) program during the following phases: preparation for participation, a 1.5-day project planning workshop, project design, implementation, results, analysis, and dissemination. Resources were then identified to help maximize learners’ efficiency progressing through each SA project phase. Project completion time estimates were provided, and this information was incorporated into all promotional program materials.

**Articulation of program time commitment.** The SCS leadership presented to its Education Standards Committee and Governing Board a detailed timeline, complete with monthly time estimates to which learners would need to commit. As both committees were comprised of leadership from each member hospital, this step was essential to ensure that learners’ institutional leaders would understand and be supportive of the commitment.
required for their faculty to complete the program. Program applicants were then required to complete a four-page learning contract, committing to the program time expectations.

**Barrier #2: Inadequate training and experience**

**Common QIPS knowledge base.** Acknowledging that learners would attend this program with a variety of pre-program experiences, the authors devised a plan to establish a common QIPS vocabulary for program communications. Learners were encouraged to complete two Institute for Healthcare Improvement (IHI) modules concerning QIPS and read an article concerning CLER in addition to the required pre-workshop assignments. Learners were also encouraged to watch additional IHI modules and attend the SCS-sponsored workshop to at least “brush up” on QIPS content prior to starting their SA project planning. A library of over 300 publicly-accessible project support materials (i.e. voiced-over PowerPoint modules regarding feasible project design, IRB applications, data set creation, analytic techniques, project tip sheets and templates, pertinent GME articles, etc.) files were made available and posted on the program course website.

**SCS faculty coaches.** The SCS Office of Faculty Development quickly recognized from learners’ pre-workshop self-assessment statements that most learners had never developed a prior SA project. The authors therefore identified themselves to serve as learner coaches for different projects based on the project focus and the coach’s areas of expertise.

**Narrowed project focus.** SCS required program learners to select one CLER pathway focus area from a list of fifteen that would comprise their project focus. Learners then designed a project with their coaches within that domain that was also in alignment with their individual health system’s priorities. By narrowing the scope of program projects in this manner, the authors could help: 1) facilitate project feasibility, 2) learners utilize available SCS resources without overextending assigned coaches, and 3) create learner project clusters for possible SA project collaboration.16-21

**Barrier #3: Lack of institutional resources**

**Communication and resource accessibility.** The authors worked to help ensure that learners would each have: 1) ready access to resources and materials for future projects, 2) a place to archive important project-related documents, and 3) a feasible
mechanism to communicate with other learners and coaches. We therefore created an online course using Desire2Learn\textsuperscript{22} course management software.

This online course site became a repository of recent articles concerning SA in GME settings, resources related to IRB application and project design, project timeline and deadline templates, discussion boards for frequently asked questions, and drop boxes for important project documentation. The drop boxes also enabled coaches to offer ongoing guidance, consultation, and feedback based on what learners had submitted.

**Learner recruitment**

The recruitment of Te4Q\textsuperscript{14} program applicants included promotional materials containing information about how participation would help them meet NAS and SA standards. Additional proposed reasons to apply included that: a) completed SA projects would improve GME education in QIPS and awareness of system errors; b) provide learners with SA skills for themselves and their residents; and c) result in systemic improvement in one specific CLER\textsuperscript{3} pathway. We successfully enrolled a total of 19 participants from 13 different SCS member systems in our first 2015-2016 cohort and 15 participants from 10 different SCS member systems in our second 2017-2018 cohort.

We have concluded that the overall process of promoting the program as an appealing GME investment primarily involved two simultaneous processes: a) obtaining “buy-in” from multiple system and residency program stakeholders, and b) adequately customizing the program to prove more feasible/appealing to potential community-based GME learners.

**Program Implementation**

In January 2015, applicants were notified of their program selection and provided a packet of pre-workshop assignments with completion deadlines and the contact information of their assigned coach. AAMC faculty primarily taught the workshop in March. Learners then worked with their coaches to refine their project, evaluate project feasibility, and prepare appropriate IRB applications.

A follow-up webinar occurred that August with AAMC faculty, SCS coaches, and learners to provide a 10-minute status report on their projects. At the end of the program in May of the next year, learners disseminated their SA project findings at a regional poster day to earn completion certificates from both the AAMC and MSU.
RESULTS

Our initial 2015-2016 cohort of 19 learners developed 15 projects, with two pairs of community-based faculty collaborating on two separate projects. Two learners withdrew from the program, one leaving the area for another GME position. Our second 2017-2018 cohort of 15 learners developed 11 projects, with one pair of participants opting to collaborate. Three learners withdrew from the program due to positional changes or competing GME position demands.

To date, about 50% of program projects have been specifically oriented to testing the implementation, delivery, and evaluation of QIPS curricula and content for either residents and/or faculty. The remaining projects addressed specific aspects of healthcare delivery processes such as surgical suite waiting times, postoperative patient follow-up calls, opioid prescribing patterns, cross-shift resident handoffs, timely reporting of critical patient lab results, assessing patients for severe sepsis, and implementing a series of group visits for patients with complex diabetes management needs.

Two projects involved education of residents concerning osteopathic manipulative medicine treatments. Those SA projects involving any protected patient health information were designed to have system Quality Improvement department personnel de-identify patient data to avoid HIPAA-related infringements and facilitate IRB approval.

DISCUSSION

We have identified the following principles for GME settings:

1. Compiling resources and streamlining project design processes can reduce learner time commitment and increase their SA project engagement.

Since community-based faculty are so often busy with patient care demands, prospective QIPS projects can be perceived as “just one more thing to be done”. Still, our Te4Q learners generally indicated that their project planning was made more manageable by proactively planning their project schedules based on provided timeline templates. Several learners also stated that the resources SCS coaches had provided
them helped them save time. Some learners placed positive comments of other posted online resources.

In hindsight, it appears that those learners who utilized available program-related resources tended to have smoother project design experiences. It was, however, also especially evident that sizable variations existed across systems (e.g. degree of QI department capability, complexity of IRB application reviews, accessibility of data-capable support personnel, potential resistance from other GME faculty) which either facilitated or impeded successful project completion.8,17,24-27

The SCS Office of Faculty Development also reviewed overall differences in project design needs between primary care and specialist providers, the extent to which different learners wanted to obtain (or avoid using) protected patient health data. The authors have concluded that regularly assessing such differences across learners’ healthcare systems will be helpful for future Te4Q cohorts. Clearly, some learners preferred to be left alone after being provided a “critical mass” of project support materials, while others preferred to exchange project updates or engage in ongoing problem-solving discussions with coaches and colleagues.11,24

2. Helping learners attain a solid QIPS knowledge base may make them more confident and capable of completing SA projects.

Most learners stated that the assigned pre-workshop IHI 15 modules and readings enhanced their understanding of QIPS concepts and project design principles. Although the QIPS workshop has probably been effective for most learners, the actual outcomes derived from such intensive content-laden events may be less helpful for more novice learners. Since different types of SA workshop/“boot camp” approaches exist,20,28 the SCS Office of Faculty Development is currently revising the workshop curriculum for future Te4Q cohorts.

3. Providing assigned coaches with compatible project-related skills can serve to keep learner SA projects moving forward.

The provision of coaches with compatible osteopathic provider, educational specialist, and project design expertise appeared to be critical for many learners during their early project planning. Similar to other settings, several program learners indicated
that they appreciated most coach feedback, as well as the accountability they felt to complete project developments to provide periodic updates for their coaches.\textsuperscript{18,29-32}

**CONCLUSIONS**

This paper summarizes the authors' experiences of delivering the AAMC Te4Q\textsuperscript{14} program to two cohorts of community-based faculty through an established GME consortium. Since both community and university-based residency program officials are now required to meet increasingly rigorous SA standards, the principles outlined in this paper may prove generalizable to the complex SA challenges of GME officials across the nation.

It will very likely take several additional cohorts of learners for the authors to determine the sustainability of programs such as Te4Q\textsuperscript{14} to enable diverse community-based GME leaders to: a) improve their capacity for SA projects, b) implement meaningful SA project supports, and c) incrementally refine key processes to sustain momentum gained from initial SA projects.\textsuperscript{23,31-33}

Several groups have suggested that the “consortium advantage” from such entities as the SCS may prove integral to more efficiently sharing SA resources and capitalizing on project-related expertise across diverse GME settings.\textsuperscript{18,25,30,31} Ideally, these paper conclusions will contribute to the development of more innovative approaches for the thousands of community-based GME programs now held to SA expectations.\textsuperscript{34,35}

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The authors declare no conflict of interest.

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- Project Implementation
- Dissemination of project (conferences, publications, etc.)
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- Month 2
- Month 3
- Month 4–5
- Month 5–6
- Month 7–12

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An Atypical Case of Transverse Diverticulitis and the Changing Management of Diverticular Disease

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ABSTRACT
OSTOSH AC, SALEH A, BOEHM KM. An Atypical Case of Transverse Diverticulitis and the Changing Management of Diverticulitis Disease. Spartan Med. Res. J. Vol. 3, No. 2, pp. 75-82, 2018. CONTEXT: Diverticulitis is an inflammation of an outpouching of the lower gastrointestinal tract, particularly in the large intestine. Although the condition is taught to medical students as typically occurring in the left lower quadrant of the abdomen, right-sided and transverse forms diverticulitis can occur. Uncomplicated, e.g., non-perforated, diverticulitis is usually treated with antibiotics. Complicated, e.g. perforated, is usually treated with surgery. The purpose of this case report is to present an atypical case of perforated diverticulitis and review current recommendations for this condition. METHODS: This was a case of transverse diverticulitis in a man in his late 40’s who recovered with non-operative treatment. The widespread use of computerized tomography (CT) scans makes diagnosing diverticular disease relatively simple, but treatment is evolving. The case summarized here shows that less invasive measures can be used in treating both complicated and uncomplicated diverticular disease. RESULTS: After an uncomplicated in-patient admission for intravenous antibiotics, the patient was discharged in stable condition with a prescription for oral antibiotics and clinic follow-up. CONCLUSIONS: Classic medical school teaching concerning treatments for complicated and uncomplicated forms of diverticulitis have been updated but require further research testing. Keywords: diverticulitis, transverse diverticulitis, antibiotic management, non-surgical management of diverticulitis

INTRODUCTION
Diverticulum are the outpouching of the large intestine. When these out pouches become inflamed, the resulting painful condition is usually located in the lower left quadrant of the abdomen. The number of hospital admissions due to diverticular disease is increasing in industrialized nations, with an increase of 26% reported in a relatively recent seven-year period.1 Typically, diverticulitis presents with clinical signs and
symptoms that make it relatively easy to diagnose: left lower quadrant abdominal pain, nausea, vomiting, and anorexia. However, atypical presentations do exist. For example, right sided diverticulitis is more commonly seen in Asian populations. In very rare cases, the disease has also been reported in the transverse colon.

METHODS

Case Report

A man in his later 40's with a history of type 2 diabetes presented to a community-based emergency department in Michigan complaining of moderate epigastric pain. The pain, which he described as constant, cramping and pressure-like with no radiation, had been gradually increasing over the past three days. Movement did not affect his pain. While he did not associate his pain with eating, he reported a decreased appetite over the same time frame. He had not tried any medications to manage his pain.

The patient had been diagnosed with type 2 diabetes one year prior and stated that his blood sugars were well controlled with his insulin doses. He had also been diagnosed with diverticulitis 10 years prior which was treated with antibiotics. After treatment, a colonoscopy was performed, which was unremarkable according to the patient. He denied any surgical history. Previously that same day, the patient had spent eight hours in a car traveling from a wedding. He reported increased alcohol consumption at the wedding the night prior. The patient stated that he typically consumes seven drinks a week and was a nonsmoker. He denied any other drug use. He often lifted heavy items for work as a beer distributor but reported no recent work-related injuries.

The patient’s vital signs on arrival were a heart rate of 119 beats per minute, a blood pressure of 163/100 mmHg., a respiratory rate of 16 and a temperature of 36.9 C. During the physical examination, the patient was found to be restless on the hospital bed, with clear lung sounds and tachycardia, but regular heart sounds. An abdominal exam found decreased bowel sounds, mild tenderness to deep palpation in the epigastric and left upper quadrant regions, and positive rebound tenderness in the left lower quadrant region. The remainder of the physical exam was unremarkable. Patient was given a 1 liter Lactated Ringer bolus and 2 mg morphine intravenous (IV) for pain.
Laboratory work was significant for leukocytosis with a 12.7 thou/mcl white blood cell count, absolute neutrophils of 9.7 thou/mcl and a lactic acid of 2.2 mMol/L. Table 1 has a complete list of lab values with abnormal labs appearing in bold font. Due to the patient’s lactic acidosis, persistent tachycardia, and left lower quadrant rebound tenderness, a computerized tomography (CT) scan of the abdomen was obtained to look for any acute abnormalities with strong suspicion of complicated sigmoid diverticulitis. Because of the authors’ high suspicion that the patient had an infectious process, he was given 500 mg of IV Metronidazole and 400 mg of IV Ciprofloxacin prior to the CT scan. The results of the CT scan (Figure 1) demonstrated acute diverticulitis located along the distal aspect of the transverse colon with signs of micro-perforation.

The General Surgery service was consulted. Since the patient appeared non-toxic, the surgeon opted to manage non-surgically with serial abdominal examinations, monitoring, and continuation of IV antibiotic therapy. The patient responded well to this conservative therapy, and was discharged three days later in stable and improved condition on oral amoxicillin/clavulanate 875mg/125mg twice daily for 14 days with follow up with the surgeon. The authors attempted to contact the patient to learn the results of the follow up appointment, but were unable to contact them.

**DISCUSSION**

Diverticulitis can be classified as either complicated or uncomplicated. Uncomplicated diverticulitis is defined as localized inflammation in the mucosa, submucosa or peri-colonic fatty tissue without perforation. Complicated diverticulitis is defined as diverticulitis with formation of an abscess, perforation or fistula. Regardless of type, diverticulitis is typically a disease of the sigmoid colon. This is due to the increased pressures associated with the sigmoid colon.

As Laplace’s Law states, pressure is equal to tension divided by radius.\(^6\) The small radius of the sigmoid colon results in increased pressure that can contribute to diverticular disease development. However, this theorem does not exclude the presence of diverticulitis in other areas of the colon. The second most common presentation is the right lower quadrant with ascending colonic disease.\(^7\) This is often confused with appendicitis and much remains unknown about this disease presentation. The prevalence
of diverticulitis in the lower right quadrant is also unknown, but it typically occurs in young males rather than elderly females, the population in which sigmoid diverticulitis typically presents.\(^7\)

The presentation of this case was strongly suggestive of complicated diverticulitis, but with the physical exam findings, it was expected to be in the sigmoid colon, not the transverse colon. The ease and availability of the CT scan makes the diagnosis of diverticulitis easy for the clinician, but the same cannot be said for choosing a course of treatment. Management of diverticulitis is evolving, and research is being done to validate the use of more conservative measures in the treatment of both complicated and uncomplicated diverticulitis.\(^8\)\(^-\)\(^10\)

The mainstay treatment of uncomplicated diverticulitis has been IV antibiotics. However, recent literature indicates that this may not be supported by current evidence-based medicine.\(^8\) The authors reviewed four sets of guidelines set by the Society for Surgery of the Alimentary Tract, the American Society of Colon and Rectal Surgeons, the European Association for Endoscopic Surgery and the American College of Gastroenterology. They determined that all guidelines recommend using antibiotics but only two, the American Society of Colon and Rectal Surgeons and the American College of Gastroenterology, referenced the original research.\(^3\)

The results of newer studies have tested antibiotic treatment of uncomplicated diverticulitis versus supportive measures to gauge the true effectiveness of antibiotics.\(^9\)\(^,\)\(^10\) One of the more promising studies includes a randomized clinical trial which enrolled a total of 620 Islandic patients diagnosed with uncomplicated diverticulitis via CT scan. Splitting the patients into two groups, one group received IV then oral antibiotic therapy and the other received only supportive measures. The two groups showed no significant difference with regards to complications or need for surgical intervention. Three patients in each group (i.e., 1.9% in non-antibiotic group, 1.0% in antibiotic group) suffered from perforation while three patients in the supportive treatment group developed an abscess.\(^10\)

The effective management of complicated forms of diverticulitis is further changing. The earlier gold standard of emergent surgical intervention is now evolving toward aggressive non-operative management.\(^11\) This is due to advancing medical technologies
and an improved understanding of diverticulitis complications. Percutaneous abscess drainage by interventional radiology has been shown to lessen the complexity of diverticulitis.\textsuperscript{2} Also, colonoscopy is being further utilized for clip placement and cautery can reduce the need for surgery in hemorrhagic diverticulitis.\textsuperscript{2} Both of these interventions may act as a bridge to surgery, but in less severe cases, they may serve as solitary treatment when combined with antibiotics.\textsuperscript{2} A notable 2011 retrospective review identified 136 patients with perforated diverticulitis. In this sample, only five (3.7\%) required emergent surgery and seven (5.1\%) required urgent surgery after failing non-operative management. A total of 124 of the 136 patients were successfully treated non-operatively, resulting in a 91\% effectiveness of non-operative treatment in this sample.\textsuperscript{11}

**CONCLUSIONS**

Although it is relatively easy to diagnose diverticulitis, deciding on the optimal course of treatment can be more complex. The treatment of this condition is changing rapidly. Recent studies have indicated that less invasive measures can be effective in treating the disease. More research needs to be completed, however, to further understand the true benefits of these less invasive measures.

Just as knowledge of how to best treat diverticular disease is evolving, more effective ways of stratifying diverticular disease are needed to standardize practice guidelines for clarifying the risks and benefits of evolving treatments. It may be time to expand from the classic complicated and uncomplicated nomenclature and look instead to a differential classification based on lab results, CT changes, and responses to management to better risk stratify future patients.

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The authors declare no conflict of interest.

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# TABLES AND FIGURES

**Table 1**
A List of Laboratory Values on Admission to the Emergency Department

<table>
<thead>
<tr>
<th>Lab</th>
<th>Patient</th>
<th>Reference value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>135 mMol/L</td>
<td>136-145</td>
</tr>
<tr>
<td>Potassium</td>
<td>4.8 mMol/L</td>
<td>3.5-5.3</td>
</tr>
<tr>
<td>Chloride</td>
<td>103 mMol/L</td>
<td>98-107</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>23 mMol/L</td>
<td>21-32</td>
</tr>
<tr>
<td>Glucose</td>
<td>129 mg/dL</td>
<td>60-100</td>
</tr>
<tr>
<td>BUN</td>
<td>12.2 mg/dL</td>
<td>8.0-22.0</td>
</tr>
<tr>
<td>Creatinine</td>
<td>1.08 mg/dL</td>
<td>0.60-1.20</td>
</tr>
<tr>
<td>Calcium</td>
<td>9.0 mg/dL</td>
<td>8.5-10.1</td>
</tr>
<tr>
<td>Alkaline Phosphatase</td>
<td>68 Units/L</td>
<td>46-116</td>
</tr>
<tr>
<td>ALT</td>
<td>28 Units/L</td>
<td>12-58</td>
</tr>
<tr>
<td>AST</td>
<td>44 Units/L</td>
<td>10-37</td>
</tr>
<tr>
<td>Bilirubin Total</td>
<td>1.2 mg/dL</td>
<td>0.1-1.0</td>
</tr>
<tr>
<td>Bilirubin Direct</td>
<td>0.1 mg/dL</td>
<td>0.0-0.3</td>
</tr>
<tr>
<td>Albumin</td>
<td>3.9 gm/dL</td>
<td>3.4-5.0</td>
</tr>
<tr>
<td>Lipase</td>
<td>92 Units/L</td>
<td>73-393</td>
</tr>
<tr>
<td>Magnesium</td>
<td>1.9 mg/dL</td>
<td>1.8-2.4</td>
</tr>
<tr>
<td>Lactic Acid</td>
<td>2.2 mMol/L</td>
<td>0.4-2.0</td>
</tr>
<tr>
<td>Hemoglobin</td>
<td>15.4 gm/dL</td>
<td>13.5-17.5</td>
</tr>
<tr>
<td>Hematocrit</td>
<td>48.6%</td>
<td>37.6-52.0</td>
</tr>
<tr>
<td>WBC</td>
<td>12.7 thou/mcL</td>
<td>3.6-11.1</td>
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<tr>
<td>Neutrophil Absolute</td>
<td>9.7 thou/mcL</td>
<td>1.7-7.6</td>
</tr>
<tr>
<td>Lymphocyte Absolute</td>
<td>1.9 thou/mcL</td>
<td>0.8-3.3</td>
</tr>
<tr>
<td>Platelet</td>
<td>282 thou/mcL</td>
<td>140-450</td>
</tr>
</tbody>
</table>

*Abnormal lab results appear in bold font*
Figure 1
CT with Contrast of Patient Showing Transverse Diverticular Disease with Micro-Perforation (Yellow Arrows) Obtained in ED

Extraluminal gas adjacent to the transverse colon consistent with microperforation.
Case Report

Colloid Cyst at the Foramen of Monro Leading to Symptomatic Obstructive Hydrocephalus

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ABSTRACT

SHAH P, FLYNN J. Colloid Cyst at the Foramen of Monro Leading to Symptomatic Obstructive Hydrocephalus. Spartan Med. Res. J. Vol. 3, No. 2, pp. 83-91, 2018. CONTEXT: A Caucasian female in her late forties presented to the Emergency Department (ED) with headache, ataxia, and mental status changes. METHODS: A CT brain demonstrated dilated lateral ventricles with transependymal edema. An MRI of the brain demonstrated marked obstructive hydrocephalus from an obstructing colloid cyst at the level of her Foramen of Monro. RESULTS: The patient was transferred to a tertiary care center for neurosurgical removal of the cyst. Three months later, the patient was doing well and had resumed all activities of daily living without any residual neurological deficits. CONCLUSIONS: The goal of this case report is to educate readers on this atypical presentation of hydrocephalus, its symptomatology, and management to allow physicians to be more comfortable in making treatment decisions. Keywords: colloid cyst, foramen of monro, hydrocephalus, emergency neurology

INTRODUCTION

A colloid cyst is considered a rare developmental malformation in the brain and not a true neoplasm, as they are benign masses, filled with proteinaceous fluid. Colloid cysts make up between 0.5% to 1% of intracranial tumors. Although rare, colloid cysts can have significant neurologic sequelae due to ventriculomegaly (i.e., a condition of the brain that can occur in the fetus wherein the lateral ventricles become dilated) caused by the mass effect, even on presentation to the ED.

METHODS

Case Report

A Caucasian female in her late forties drove to our ED with a chief complaint of headache. Her headache had been persistent over the past eight days. She characterized
Colloid Cyst at the Foramen of Monro Leading to Symptomatic Obstructive Hydrocephalus

it as a constant, throbbing sensation localized to the frontal aspect of her head. She admitted to experiencing prior migraine headaches, however, she noted that this particular instance felt different. The patient denied maximal intensity upon onset of symptoms. She denied photophobia, phonophobia, or any other neurological deficits. When her headache started, she had a concurrent upper respiratory infection. She was prescribed Promethazine 25 mg PO at an urgent care facility. According to patient’s boyfriend, ever since she started taking Promethazine, she had been acting “different.”

The night before her arrival to our ED, the patient had worked a long shift as a valet driver. Upon arriving home, she took a dose of Promethazine and fell asleep. Upon arriving to work the following morning, her coworkers noted that her car had large dents on the front bumper. When she got out of the car, she was wearing a short skirt and mismatched high heels despite the frigid outside temperatures. She was ataxic and speaking incoherently and was sent to our ED for evaluation.

Upon arrival to the ED, the patient had stable vital signs. Her medical history was significant for hypertension. Her physical examination was unremarkable apart from neurological examination. When asked the date, the patient responded “October 1967.” Her head appeared normocephalic. There were no meningeal signs. Her speech was incoherent. Finger to nose testing was dysmetric with tendency to overshoot. Additionally, she was ataxic with broad gait.

Considerations were given to possible adverse drug reaction to Promethazine, other toxic or infectious etiologies, or structural lesions. Laboratory studies were within normal limits. While waiting to receive a CT scan of her brain, a bedside ocular ultrasound was performed which demonstrated an optic nerve sheath diameter less than 5 mm. without evidence of papilledema. Her CT brain without IV contrast demonstrated dilated lateral ventricles with associated transependymal edema. (Figure 1) An emergent MRI of the brain without contrast was completed to identify a colloid cyst at the level of the Foramen of Monro measuring 1.3 x 1.3 cm. (Figure 2) There was marked obstructive hydrocephalus and cerebral sulcal effacement seen in the image consistent with cerebral edema. The patient was admitted to our hospital for evaluation by the Neurology and Neurosurgery teams.
The Neurosurgery service recommended transferring the patient to a tertiary care facility for open craniotomy and resection of the colloid cyst. At the tertiary care hospital, a right craniotomy was performed. A colloid cyst was identified at the roof of the third ventricle extending into the lateral ventricles through the Foramen of Monro. The cyst was subsequently dissected out. An external ventricular drain (EVD) was kept at the patient’s Foramen of Monro. The EVD device was removed at 2-week follow-up. On interview with the patient three months following surgery, she was feeling much better and has resumed employment as a valet driver.

**DISCUSSION**

A colloid cyst has a wall lined with epithelial and goblet cells secreting protein-rich fluid. While this condition is considered a rare developmental malformation and not a true neoplasm, it does occur in approximately between 0.5% to 1% of intracranial tumors. Typically, this type of cyst can occur at any age but people generally do not become symptomatic until the third to fifth decades of life. In 99% of cases, it is found posterior to the Foramen of Monro and arises from the anterior roof of the third ventricle. At the level of the Foramen of Monro, the cyst may prevent drainage of cerebrospinal fluid from the lateral ventricles to the third ventricle. In effect, hydrocephalus and resulting transependymal edema from the increased intracranial pressure (ICP) may be seen, as was the case for this patient. Colloid cysts carry a risk of mortality ranging from 3.1 to 10%.

Depending on the extent of ventriculomegaly, patients may present with neurological symptoms ranging from headaches to herniation. The triad of “wet, wacky and wobbly” is often found in medical school exams, all of which can be found in patients with hydrocephalus associated with obstructing colloid cysts. Papilledema may also be present due to ICP causing pressure on the optic nerve sheath. For this reason, it is important to check the patient’s vision and test the optic nerve with visual acuity and visual field testing.

In a study of 155 patients with newly diagnosed colloid cysts, Pollock et al. discovered that symptomatic colloid cysts were associated with 4 main variables: patient age, cyst size, ventricular dilation, and signal strength on T2 weighted MRI. Younger
patients, 44 years old versus 57 years old (p < 0.001) were more symptomatic. Patients with larger cyst size, 13 mm. versus 8 mm. (p < 0.001) were also more symptomatic. Patients with increased ventricular dilation of 83% versus 31% (p < 0.001) also displayed more symptoms. Finally, increased signal on T2-weighted MRI, 44% versus 8% (p = 0.001) tended to be more symptomatic. The most significant variable of these was ventriculomegaly. Patients with larger ventricles were more symptomatic.10

In 2016, Beaumont et al. published the Colloid Cyst Risk Score (CCRS), a method used to stratify the risk of a patient to develop obstructive hydrocephalus and guide physicians to choose appropriate treatment pathways. Patients with a CCRS ≥ 4 are considered at high risk for lesion progression and obstructive hydrocephalus. One point is given for age below 65 years, one point for presence of headache, one point for axial diameter of cyst >7 mm., one point for FLAIR (i.e., fluid attenuated inversion recovery) hyperintensity on MRI, and one point for location of the colloid cyst in the risk zone. According to this scale, our patient would have been assigned a CCRS of 5 and did in fact have obstructive hydrocephalus requiring surgery.

Imaging studies are essential in the workup of patients presenting with symptoms suggestive of possible hydrocephalus. A CT brain without contrast is the initial test of choice. Approximately 2/3 of colloid cysts appear hyperdense on imaging. The lesions are usually round or ovoid and are well delineated. Most cysts range between 5-25 mm.10 The appearance of colloid cysts on MRI is important for neurosurgeons, because the surgical success rate is lower in colloid cysts that have decreased MRI T2-signal intensity.11 It is also important to keep in mind that lumbar puncture can be fatal as non-draining obstructive hydrocephalus can lead to herniation. An ophthalmologic evaluation may be useful if diplopia is a presenting complaint or if papilledema is found on physical examination as this may be a marker for increased ICP.9

Various management options exist depending on the severity of a patient’s symptoms. For patients who are symptomatic and have a higher degree of ventriculomegaly, more immediate surgical options include craniotomy for microsurgical resection, neuroendoscopic removal, and cerebrospinal fluid diversion with ventriculoperitoneal (VP) shunts.12,13 In our patient’s case, she did have symptomatic
hydrocephalus as a result of the obstructing colloid cyst and underwent a craniotomy. In asymptomatic patients, conservative management with serial MRIs is preferred.\textsuperscript{12}

Microsurgical resection through the transcortical-transventricular or transcallosal approach is considered the standard of surgical treatment for symptomatic patients.\textsuperscript{13} The transcortical approach involves a craniectomy over the middle frontal gyrus. This transcortical approach carries an increased risk of postoperative epilepsy. Other possible complications include hematoma, memory deficits, mutism, and hemiplegia.\textsuperscript{14}

CONCLUSIONS

Although rare, colloid cysts can have significant neurologic sequelae as seen in this patient’s case. The case reported here was a unique presentation to the ED given her age and significant ventriculomegaly from obstructing hydrocephalus. She presented with persistent headache, altered mental status, and ataxia. Her MRI displayed a colloid cyst at the level of the Foramen of Monro that was surgically dissected. The goal of this case report is to familiarize readers with the presentation, symptomatology, and management associated with colloid cysts. After reading this report, we hope that clinicians will consider this condition as a differential diagnosis in those patients who present with acute neurologic changes similar to our patient.

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REFERENCES


TABLES AND FIGURES

Figure 1
CT of the Brain without Contrast

A: Axial image demonstrating dilated lateral ventricles with transependymal edema

B: Axial image demonstrating possible obstructive pathology at the level of the Foramen of Monro
Figure 2
MRI of the Brain without Contrast

A: T2 weighted sagittal image demonstrating a colloid cyst measuring 1.3 cm by 1.3 cm at the level of the Foramen of Monro.

B: FLAIR image displaying hyperintense signal at the Foramen of Monro consistent with colloid cyst.
C: T1 weighted axial image displaying isotense to gray matter signal at the level of the Foramen of Monro consistent with colloid cyst.
Case Report

A Novel Treatment of Acne Fulminans with Adalimumab: A Case Report

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ABSTRACT

RAJAIII R, GLOBERSON J, ARNOLD N, MAHON M. A Novel Treatment of Acne Fulminans with Adalimumab: A Case Report. Spartan Med. Res. J. Vol. 3, No. 2, pp. 92-99, 2018. CONTEXT: Acne fulminans (AF) is a rare and highly inflammatory severe form of acne most commonly seen in adolescent males. Unlike acne vulgaris, AF presents with associated systemic manifestations including, but not limited to, malaise, myalgia, arthralgia, fever, anorexia, and weight loss. It is often an extremely painful condition of sudden onset and can occur years after mild or moderate acne vulgaris. While the inciting agent for this condition has been postulated to be an explosive hypersensitivity reaction to the bacterium Propionobacterium acnes, increased androgens, namely testosterone, have also been reported to play a role in the pathogenesis of this disease process. Additionally, environmental triggers such as air pollution and exposure to halogenated hydrocarbons during occupational activities in enclosed, high temperature settings have been identified as possible etiologies or exacerbating factors. AF is primarily a clinical diagnosis. Isotretinoin, in combination with systemic steroids, are generally the treatments of choice for this disease entity. METHODS: A Caucasian male in his early 40’s presented to the authors’ clinic with a chief complaint of painful acneiform nodules, cysts, papules, pustules, and abscesses on his back, chest, neck, shoulders, upper arms, and thighs for several months. RESULTS: This case report demonstrates a refractory case of AF with significant clinical improvement after six weeks of topical treatment with subcutaneous adalimumab in combination with oral doxycycline. CONCLUSIONS: This case provides evidence supporting the role of Adalimumab in the treatment of AF in addition to the other inflammatory conditions currently FDA approved for treatment with this tumor-necrosis factor (TNF) alpha inhibitor. These conditions include plaque psoriasis, Crohn’s disease, hidradenitis suppurativa, psoriatic arthritis, and rheumatoid arthritis. Keywords: acne fulminans, adalimumab, humira, tnf-alpha inhibitor

INTRODUCTION

Acne fulminans (AF) is a rare, highly inflammatory and severe form of acne presenting with an eruption of painful nodules, pustules, and hemorrhagic ulcerations in association with systemic manifestations such as fever, arthralgia, myalgia, hepatosplenomegaly, leukocytosis, anemia, and increased inflammatory lab markers including TNF-alpha.1 This painful condition usually presents itself in young adolescent
males with a previous history of moderate acne vulgaris. The pathogenesis appears to be multifactorial.\textsuperscript{1,3}

AF is primarily a clinical diagnosis and treatment is often challenging at best. To date, combination therapy with isotretinoin and systemic corticosteroids have been the treatments of choice.\textsuperscript{1,2,4,5,6,7} Novel studies using tumor-necrosis factor alpha (TNF-alpha) inhibitors have shown great promise for recalcitrant inflammatory conditions such as plaque psoriasis, Crohn’s disease, hidradenitis suppurativa, (i.e., inflammatory skin disease that affects apocrine gland bearing skin in axillae, groin, etc.) psoriatic arthritis, and rheumatoid arthritis in various medical settings.\textsuperscript{7} The markedly inflammatory nature of AF and success of TNF-alpha inhibitors in treating other chronic inflammatory conditions suggests their possible applicability in the management of AF.

METHODS

Case Report:

A Caucasian male in his early 40’s presented to the authors’ Dermatology clinic with a chief complaint of painful acneiform nodules, cysts, papules, pustules, and abscesses on his back, chest, neck, shoulders, upper arms, and thighs for several months. He reported a history of mild acne throughout his adolescence and early adulthood prior to this eruption. His associated symptoms included tenderness, swelling, pain, and drainage in the areas affected by these acneiform papulonodules and abscesses, most notably on the back, chest, and shoulders.

He reported constitutional symptoms of arthritis and occasional fevers but denied chills, night sweats, myalgia, malaise, and weight loss. He had failed previous treatment with multiple oral and topical antibiotics over a course of approximately one year, isotretinoin therapy for roughly six months, and phototherapy, oral/intralesional steroids, and incision/drainage. Each of these treatments had been delivered on an as-needed basis.

On examination, this patient demonstrated widespread erythematous (i.e., reddened) and inflamed acneiform nodules, cysts, papules, pustules, and abscesses on his back, chest, neck, shoulders, upper arms, and thighs. (Figure 1) Several cysts were fluctuant (i.e., compressible) and tender with active serosanguineous (i.e., containing both
blood and serum) drainage. On further exam, he had widespread ill-defined hyperpigmented patches. The worst areas of involvement included the trunk, namely the back.

RESULTS

This man was diagnosed with AF and started on a treatment regimen of topical and oral medications including topical clindamycin and Tretinoin, once weekly phototherapy, Oral medications included Doxycycline 100 mg twice daily, isotretinoin, and oral and intralesional steroids, all with minimal improvement after a total of 12 months.

Due to his limited multi-therapy success, and after appropriate preliminary laboratory evaluation, he was started on the following subsequent regimen: continuation of Doxycycline and initiation of self-administered subcutaneous injections with 40 mg of adalimumab every two weeks. After only six weeks of treatment on this new regimen, he exhibited a significant reduction in inflammatory nodules, cysts, papules, pustules, and abscesses. (Figure 2)

DISCUSSION

AF is a rare and severe form of inflammatory acne characterized by the abrupt onset of painful nodules, pustules, and hemorrhagic ulcerations in association with systemic manifestations including fever, arthralgia, myalgia, hepatosplenomegaly, leukocytosis, anemia, and increased inflammatory lab markers such as TNF-alpha levels.

Additionally, osteolytic bone lesions (i.e., “punched-out” areas of severe bone loss) may be detected, most commonly involving the clavicle and sternum.¹ AF primarily affects the face, neck, arms, back and chest of adolescent boys age 13-16 with a previous history of mild or moderate acne vulgaris.² The pathogenesis appears to be multifactorial, and it is postulated that the condition is prompted by an explosive hypersensitivity reaction to Propionobacterium acnes, increased androgens, namely testosterone, and environmental triggers such as air pollution and exposure to halogenated hydrocarbons in occupational high temperature settings which promote occlusion and excess sweating.¹,³
Although various options have been described, the treatment of AF remains a challenge for clinicians. The current recommendations suggest a combination treatment with systemic oral prednisolone and oral isotretinoin. Suekeran and Cunliffe’s 1999 review of 25 cases recommended 0.5 - 1.0 mg/kg oral prednisolone daily for 4-6 weeks with the addition of oral isotretinoin therapy starting in the fourth week at a dose titrated up from 0.5 mg/kg daily. The total duration of treatment has been variable and in one review ranged from nine months to two years.

Conventional treatments with oral antibiotics, topical corticosteroids, and nonsteroidal anti-inflammatory drugs have been used without significant improvement or sustained remissions. Although effective management can be challenging, recurrent AF has been rarely reported. The markedly inflammatory nature of AF and success of TNF-alpha inhibitors in treating other chronic inflammatory skin disorders such as plaque psoriasis and hidradenitis suppurativa has led dermatologists to prescribe these medications off-label (i.e., for indications yet to be approved by federal officials) for resistant acne.

Since the mid-1990s to early 2000s, a more complete understanding of immunology and advances in biologic drug development has popularized the use of TNF-alpha inhibitor therapy. Adalimumab is a recombinant human monoclonal antibody that binds to TNF-alpha thereby halting the progression of the cytokine driven inflammatory cascade. Recent reports of TNF-alpha inhibitor therapy for severe inflammatory acne postulate their use and efficacy in patients with AF and provide the impetus for the use of subcutaneous adalimumab in our patient with refractory AF.

Early reports of TNF-alpha inhibitor use to control AF lesions involved patients with SAPHO syndrome (Synovitis, Acne, Pustulosis, Hyperostosis, and Osteitis) who had failed conventional treatments. SAPHO syndrome is a rare chronic inflammatory disease of unknown etiology that may accompany AF and other cutaneous manifestations including acne conglobate (AC), acneiform folliculitis, HS, psoriasis, Sweet syndrome, and pyoderma gangrenosum.

It has been well established that patients with SAPHO syndrome have elevated levels of TNF-alpha from purified neutrophils as well as in bone biopsies analyzed with in situ hybridization and immunohistochemistry. Treatment of these patients with infliximab
and etanercept has demonstrated reductions in neutrophil TNF-alpha, resolution of acneiform lesions, and durable responses. These results suggest that components of SAPHO syndrome including AF result from an abnormal immunological response to Propionobacterium acnes, and that TNF-alpha inhibitors may be indicated for certain cases of recalcitrant acne and AF.

Recently, TNF-alpha inhibitors adalimumab, etanercept, and infliximab have been used to treat resistant AC, a variant of severe inflammatory acne and part of the follicular occlusion tetrad (i.e., AC, hidradenitis suppurativa, dissecting cellulitis and pilonidal disease). Two case reports describe patients responding to adalimumab monotherapy after failing conventional treatments for recalcitrant AC. After four weeks of treatment with adalimumab, most of the inflammatory lesions had resolved, and after 12 weeks all of the nodular lesions had cleared entirely in both case report patients. No adverse events or abnormal laboratory tests were reported in these cases.

Additionally, one patient with AC of the face, neck, and trunk responded to treatment with etanercept demonstrating complete resolution of acneiform lesions at 24 weeks. In 2006, Shirikawa presented a patient with concomitant rheumatoid arthritis and AC who failed isotretinoin due to adverse effects. Infliximab therapy was initiated, and a rapid reduction in the number and size of cystic lesions was appreciated. The literature and our case report suggest that TNF-alpha inhibitors can provide clinicians with a reliable and efficacious treatment for patients suffering from severe inflammatory acne refractory to other treatment modalities.

CONCLUSIONS

The results published in the recent literature support the mechanism and role of TNF-alpha inhibitors in the treatment of recalcitrant inflammatory acne. Our case report further supports these results and provides additional evidence for a role of TNF-alpha inhibitors in the treatment of such resistant inflammatory disorders including AF. While the evidence appears promising, current recommendations for treatment of AF remains a combination of oral isotretinoin and systemic steroids.
Further research in this area is needed to elucidate the efficacy and most appropriate use of TNF-alpha inhibitors in the setting of inflammatory acne, particularly cases that have failed the current standard of care.

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A Novel Treatment of Acne Fulminans with Adalimumab: A Case Report

TABLES AND FIGURES

Figure 1
Acne Fulminans Presenting with Widespread Erythematous and Inflamed Acneiform Nodules, Cysts, Papules, Pustules, and Abscesses on the Back.

Figure 2
Acne Fulminans after Six Weeks of Treatment on Combination Therapy with Doxycycline and Adalimumab. A Significant Reduction in Inflammatory Nodules, Cysts, Papules, Pustules, and Abscesses Was Seen on the Back.
Contacting Patients After an Emergency Department Visit to Influence their Follow-Up Care Preferences

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ABSTRACT


CONTEXT: Emergency Departments (ED) have faced increasing challenges in providing quality, cost-effective patient care. In addition, healthcare administrators have sought specific techniques to improve patient perceptions of care and satisfaction as a component of Medicare reimbursement and physician contract retention. This five-month study sought to examine whether contacting patients per phone or leaving them a voicemail message after an ED visit might influence their perceptions of care and subsequent follow-up care preferences.

METHODS: A sample of 95 discharged ED patients were contacted by phone and mailed surveys rating their likelihood of return directly for future ED as well as scheduling office-based visits. Patients were stratified by whether they were: a) directly spoken to over the phone, b) left a voicemail message, or c) never successfully contacted. Mailed patient surveys utilized a five-point Likert-type scale items concerning future follow-up care preferences. Sample patients were also monitored in the electronic health record to correlate self-reported intentions with whether they actually returned to the same ED for the same chief complaint within 30 days of their initial visit.

RESULTS: Those patients who were directly contacted after ED discharge tended to be more likely to report they would return to the same ED, although not significantly (p = 0.060). Patients who were left a voicemail message were not more likely to return to the ED (p = 0.230). However, patients who were contacted directly indicated that they were more likely to adhere to received discharge instructions (p = 0.010). Neither did phoning patients significantly influence whether they followed-up with clinic providers (p = 0.999) or return to the same ED within 30 days (p = 0.999).

CONCLUSIONS: Although there are often many complex factors influencing patients’ post-ED care decisions, the results from this smaller project indicated that contacting patients after ED discharge may help influence their perceptions of care and influence some follow-up care preferences.

Keywords: emergency department care, post-discharge phone call, patient follow-up
INTRODUCTION

Emergency Departments (ED) continue to face challenges in providing efficient, quality care in a climate of increased patient visits, longer waiting times, increased focus on hospital metrics, and a heightened emphasis on different aspects of patients’ perceptions of care.¹-⁴ Hospital officials value patients’ overall satisfaction due to financial incentives (e.g., Medicare reimbursements) from reporting by entities such as Press Ganey Associates.⁵ As such, increased attention has been paid towards developing methods to improve patient perceptions of their care and future care preferences.³,⁶,⁷

The authors’ ED was similar to many departments in trying to identify cost-effective strategies to improve patient satisfaction in a climate where the volume of ED visits were at an all-time high.⁸ One proposed method was to contact patients by phone after ED discharge to inquire about their care perceptions and overall patient satisfaction. This prompted the authors to consider follow-up communication as an avenue of improvement at our healthcare system. However, the authors found that physicians were generally unable to contact patients after their ED visit for the purpose of obtaining patient follow-up communication.

Further, several studies have demonstrated a two-fold positive increase in perceptions of care received and likelihood to recommend a specific ED based on calling patients after ED discharge.⁶,⁷,⁹ There has also been renewed interest in other ways to attempt subsequent contact with former ED patients, including emails. For example, patients’ perceptions of ED care have been shown in one study to be higher when physicians later emailed patients.¹⁰ In addition, the results from two larger studies demonstrated an increased likelihood of patients to recommend an ED to friends and families after receiving a post-discharge phone contact.¹¹,¹²

Purpose of Study

The overall goal of this study was to investigate whether phoning patients who had completed a community-based ED visit influenced their later preferences concerning follow-up care and perception of our ED. The authors’ specific objectives were to identify whether contacting patients after ED discharge may influence their adherence with discharge instructions, whether they may be more likely to follow up with clinic-based providers, or if they were more likely to return to the same ED if changes in their conditions
indicated. The authors also collected data concerning other factors previously shown to influence ED patient care perceptions such as wait time before receiving care, total hours of ED length of stay, etc.\textsuperscript{13,14}

**METHODS**

This study was a prospective descriptive study conducted between September 2017 through January 2018. Eligible patients had been evaluated and discharged from the authors’ community-based ED in the Detroit Michigan area, a Level II Trauma Center with 72,000+ annual visits. When possible, sample patients were phone contacted by the authors between 24 to 48 hours after ED discharge and either: a) spoken to directly, b) left a voicemail message, or c) recorded as never successfully contacted. In addition, paper surveys created by the authors with return self-addressed stamped envelopes were sent to each patients’ reported home address. Please see Figure 1 for an overall study flowchart detailing the ED visit to follow-up phone call to mailed survey process, and Figure 2 for a mailed paper survey template.

Patients with a documented history of a psychiatric illness, those who had left against medical advice (AMA) or left without completion of services were excluded from the study. If a patient was not directly contacted, a scripted voicemail message prompt was left to protect patient information. (Figure 1, bottom right) The authors institutional review board had approved the study prior to data collection.

**Study Outcomes**

The first study outcome concerned whether patients were more or less likely to return to the same ED assessed on a five-point Likert-type scale survey. Patients who reported “5” were “very likely” to return to the ED versus “1” were “not very likely” to return for future evaluation. The authors hypothesized that patients who were phone contacted soon after ED discharge would be more satisfied with the overall care provided and more likely to return to the our ED again for future evaluations if needed.

Patients were also asked to report whether they had decided to: (a) adhere to ED discharge instructions and b) make a follow-up appointment with a clinic-based provider. During the study period, sample patients were also monitored in the electronic health record (EHR) for any returns to the same ED within 30 days for re-evaluation of the same
Contacting Patients After an Emergency Department Visit to Influence their Follow-up Care Preferences

chief complaint. Sample patients were monitored for return to the same ED to determine if speaking with patients after their ED discharge would help clarify their discharge instructions and manage their post-discharge expectations.

We had hypothesized that patients who were contacted on the phone would be more adherent to discharge recommendations. We also expected that patients who were spoken to after discharge would be more likely to follow-up with their clinic-based provider. We had also anticipated that patients who were directly spoken to would be less likely to return to the same ED for the same chief complaint within 30 days as contacted patients would be provided more guidance/reassurance to potentially circumvent their need to return to the ED.

Data Analyses

Categorical data were summarized as counts and percentages. Survey responses “one” through “four” were grouped and compared to patients who reported “five” which is similar to how Press Ganey categorized survey responses. Between-group mean differences were first compared by calculating t-tests for independent measures (i.e., age, sex, number of past medical conditions, number of diagnosed conditions in ED, emergency severity index, wait time before receiving care, and length of stay). Categorical data were then compared using the chi-square test or Fisher’s exact test. For all analysis, a two-tailed p-value < 0.05 was observed as statistically significant.

Following the authors’ initial data entry using Microsoft Excel, Minitab 18 Statistical Software (State College, PA), or Langsrud online calculator were used by the campus-based analyst (see acknowledgements) to conduct selected analyses.

RESULTS

There were a total of 96 (21.7%) surveys returned from the 443 sent to discharged ED sample patients. One response was excluded from analysis as no items were answered. Returned surveys were also divided into three sample subgroups: a) contacted over the phone (n = 65, 69.1% of total sample), b) left a voicemail message (n = 10, 10.6%), and c) never successfully contacted (n = 19, 20.2%). Prior to inferential analyses, independent variables (i.e., age, sex, number of past medical conditions, emergency
severity index, wait time, length of stay (LOS)) were compared among the three sample subgroups with no statistically significant differences found. (Table 1)

As shown in Table 2, patients who had been first phone contacted then self-reported via survey a somewhat higher likelihood of returning to the same ED as needed in the future compared to self-reported survey response patients who were never contacted, although not to a statistically significant degree (p = 0.060). Patients who were left a phone message after ED discharge were not significantly more likely to self-report intentions to return to the same ED again for future evaluations (p = 0.230). (Table 2)

Additional outcome measures concerned whether phoning patients after discharge influenced their self-reported intent of following discharge instructions, self-reported intent to follow-up with a clinic-based provider, and the rate of return visits to the same ED. Patients who were phone contacted were significantly more likely to self-report an intention to follow discharge instructions compared to never-contacted patients (p = 0.010). However, speaking with patients did not significantly influence their self-reported intent of scheduling a follow-up with clinic providers (p = 0.099). Although a greater number of patients who were phone contacted returned to the same ED for the same chief complaint within a 30-day period (10 of 65, 15.4%) than non-contacted patients (3 of 19, 15.8%), this difference could not be inferentially examined due to inadequate frequency volume (i.e. small sub-sample) (p = 0.999).

**DISCUSSION**

These results indicate that patients who were phone contacted after ED discharge tended to self-report a higher intent of adhering to discharge instructions, although not of returning to the same ED again for future evaluations. This finding matches a Cochrane meta-analysis examining post-discharge phone calls and patient expectations of care which did not find improved patient satisfaction from contacting patients.¹⁶ Neither did phone contacting sample patients after ED discharge result in an increased self-reported likelihood of intent to follow-up with a clinic-based provider.

Each sample patient spoken with on the phone self-reported following their ED discharge instructions. This finding was in agreement with studies showing increased discharge instruction adherence in patients discharged after hospital admission.¹⁷ We
have since concluded that additional phone conversations concerning patients’ current medical conditions and what medications or further interventions might be needed if their symptoms changed.

These results failed to reveal a statistically significant reduction in return ED visits for the same chief complaint within a 30-day period. This finding is in agreement with previous studies showing that follow-up phone calls had not influenced 30-day hospital re-admission rates.\textsuperscript{18} However, this finding conflicted with a previous study showing a follow-up phone call reducing return visits within 30 days compared to non-contacted patients.\textsuperscript{19} Notably, four (6.3\%) of the 64 patients who were successfully contacted were advised to return to the ED and ended up being admitted due to changes in their clinical conditions identified by interviewers. This finding suggests that speaking with some patients after ED discharge may provide an opportunity for risk mitigation as patients’ clinical conditions may change despite earlier ED care.

We acknowledge that our study results were likely affected by several design limitations. Some phone numbers used to contact patients that had been entered into the EHR may have been incorrect. These findings are based on patients’ self-reports about their adherence to discharge instructions and actual follow-up with clinic provider that could not be realistically confirmed. Although our sample size was smaller than some cited studies, our 21.7\% survey response rate was similar to related studies.\textsuperscript{10-12} We should also acknowledge that some of our phone interview or survey questions may have been unclear to some patients.

**CONCLUSIONS**

These results suggest that contacting certain higher-risk patients after their ED visit may be an effective strategy for helping influence follow-up care preferences and could improve perceptions of earlier ED care. Such interventions may also increase the likelihood of some patients to return to a familiar ED facility when needed. This can be an especially important step in coordinating patient care between ED and other clinic-based providers to help them avoid further health problems. A post-ED visit phone call may also convey to patients a level of concern and compassion that they may not have perceived during typically rushed ED encounters.
As ED physicians, we are tasked with treating a range of medical conditions while maintaining a high level of patient satisfaction. Strategies to influence care perceptions by former ED patients need to be further studied. Contacting patients after their ED discharge continues to be an intriguing potential strategy requiring further evaluation.

The authors declare no conflict of interest.

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1. Robert Jarski, Ph.D., P.A. of Oakland University School of Health Sciences for providing statistical support and analyses;

2. Costandinos Tsagaratos, D.O. for taking an initial form of the survey and transcribing the revised study survey into the electronic health record for discharged patients.

3. Financial support for this project was also provided by a MSU Statewide Campus System 2017 Resident Research Support Grant.

4. The overall study findings were presented during an oral presentation at the Michigan College of Emergency Physicians Research Forum (April 2018).
REFERENCES


TABLES AND GRAPHS

Table 1
Patient Subgroup Characteristics

<table>
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<th></th>
<th>Spoke to Group (n = 65)</th>
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<td>Wait Time (in minutes)</td>
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<td>10.1</td>
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<td>LOS (in minutes)</td>
<td>216.9</td>
<td>230.8</td>
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Table 2
Phone Contact Frequencies

Chi-square analysis on likelihood of patients to return to ED for further evaluations. A) Patients who were spoken to trended to an increased likelihood of returning to the ED for future evaluations when compared to patients that were not contacted after ED discharge (p = 0.06). B) Patients who were left a message were not more likely to return to the ED for further evaluation when compared to patients that were not contacted after ED discharge (p = 0.23).

A

<table>
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<td>12</td>
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B

<table>
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<td>12</td>
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<td>Responded 5</td>
<td>5</td>
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Figure 1

Study Flowchart, Inclusion and Exclusion Criteria, Voice Message Prompt

Patient called 1-2 days after ED discharge

- Spoke to Patient
- Left voice Message
- No answer
- No message:

Survey sent with return envelope/postage

Group 1
Returned survey of patients spoken to

Group 2
Returned survey of patients left a message

Group 3
Returned survey of patients NOT contacted

Inclusion Criteria
M/F > 18
M/F >18 (Guardians returned survey)
M/F <18 (Parents returned survey)

Exclusion Criteria
Patients who left AMA/LWCS
Psychiatric patients

Voice Message Prompt
“Hello, this is Dr. [resident] at Henry Ford Macomb Hospital. I am calling to see how you are feeling after your visit to our Emergency Department. If there are any questions or concerns, you can follow-up with your primary care physician or give us a call in the Emergency Department. Hope you are feeling better.”
Figure 2
Mailed Patient Survey

[Patients Name] MRN: [Patients MRN]

Dear [Patients Name]
[Patient Address]

You have been automatically enrolled in a research project at Henry Ford Macomb Hospital. This study is optional but has the potential to greatly improve patient care at our facility. If you are willing to participate, please fill out the attached survey and return in the enclosed stamped envelope.

The protection of your personal information is very important to us. Specific patient information will be only handled by the private investigator. Your personal information is masked with a 4 digit number. All personal information will be destroyed after the survey is sent to you. No information on your conditions or why you were seen will be stored.

The information will not be shared with any other persons or institutions.

If you have any questions or concerns, please do not hesitate to call.

Sincerely,

Matthew C. Bombard, D.O.
Chief, Emergency Medicine Resident PGY IV
Michigan State University College of Osteopathic Medicine, Clinical faculty

HF MACOMB EMERGENCY
15855 19 Mile Road
Clinton Township MI 48038
[Emergency Department phone number]

ER Visit Date ___________ Survey ID __________

Patient Callback Survey

1. Were you examined and/or treated in the hallway or a room?
   A. Hallway
   B. Room

2. Did the Emergency Medicine Resident speak with you AFTER your Emergency Department visit?
   A. YES, I spoke to the resident (Go to Question 3)
   B. NO, I was left a message (Go to Question 4)
   C. There was no phone call or voice message (Go to Question 5)
3. **ANSWER ONLY IF YOU SPOKE WITH A RESIDENT.** Did that interaction AFTER your Emergency Department visit make you more or less likely to visit the Emergency Department again?

1 - Not very likely
2 - Not likely
3 - No opinion
4 - Likely
5 - Very likely

4. **ANSWER ONLY IF A RESIDENT LEFT YOU A MESSAGE.** Did the voice message AFTER your Emergency Department visit make you more or less likely to visit the Emergency Department again?

1 - Not very likely
2 - Not likely
3 - No opinion
4 - Likely
5 - Very likely

5. **ANSWER ONLY IF NO ONE CONTACTED YOU AFTER YOUR ER VISIT.** Would a follow up phone call after your Emergency Department visit make you more or less likely to visit the Emergency Department again?

1 - Not very likely
2 - Not likely
3 - No opinion
4 - Likely
5 - Very likely

6. Did you continue the plan that was made in the Emergency Department?

YES
NO

7. Did you make an appointment with your Primary Care Physician (or a PCP to follow up with) after your Emergency Department Visit?

YES
NO

Thank you for completing this survey. Your response is important to providing a better experience for your next visit.
Correlation of Clinical Factors and Audiometric Characteristics with MRI Findings in Patients with Asymmetric Sensorineural Hearing Loss

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2 McLaren Oakland Hospital, Pontiac, MI
3 Statewide Campus System Michigan State University College of Osteopathic Medicine, East Lansing, MI
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5 North Oakland Ear, Nose & Throat Centers P.C. and McLaren Oakland Hospital, Pontiac, MI

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The review of this manuscript was coordinated by SMRJ Chief Editor William Corser

ABSTRACT

VU Q, KO E, WISNIEWSKI SJ, CARPENTER G, LAUR H, SHERMETARO C. Correlation of Clinical Factors and Audiometric Characteristics with MRI Findings in Patients with Asymmetric Sensorineural Hearing Loss. Spartan Med. Res. J. Vol. 3, No. 2, pp. 113-122, 2018. CONTEXT: To identify the presence of any correlative factors between presenting symptoms and characteristics of asymmetrical sensorineural hearing loss on audiogram, and if retrocochlear pathology was identified on MRI in patients presenting in a private practice setting. METHODS: A retrospective study of patients meeting inclusion criteria who underwent MRI for asymmetric hearing loss between March 2014 to March 2017 was reviewed using Allscripts electronic health records. This data was then compiled in an excel spreadsheet and submitted for statistical analysis. RESULTS: Of the initial 687 study patients, N = 303 patients met the inclusion criteria for review. Of these 303, 48 patients (15.8%) had abnormal MRI findings. Chi-square analysis performed showed no significant association of varied clinical variables (e.g. uni and bi-lateral tinnitus, vertigo, etc.) with abnormal MRI. Point Biserial Correlation analysis revealed no statistically significant correlations, with the exception of that between AS (Left Ear) 6 kHz and MRI lesions (r = -0.115, p = 0.045). Logistic and multinominal logistic regression analysis used to calculate odds ratios showed that for patients with hearing loss at the 6 kHz (dB) level, there is a very slightly lower, statistically significant likelihood of lesions showing up on MRI (OR, 0.984 (95% CI, 0.970-0.998), p = 0.0251). CONCLUSIONS: The results lead to the conclusion that there may be an association between experiencing hearing loss at the level of 6 kHz and a slightly lower chance of the presence of retrocochlear lesion noted on MRI. Keywords: asymmetrical sensorineural hearing loss, audiogram, magnetic resonance imaging
INTRODUCTION

When a patient presents with asymmetrical sensorineural hearing loss, a variety of etiologies must be considered. These causes may arise from a number of categories including: infectious, pharmacologic ototoxicity, acoustic trauma, metabolic or autoimmune disorders, and neoplasms. The current gold standard for further evaluation of asymmetrical sensorineural hearing loss is gadolinium-enhanced magnetic resonance imaging (MRI). MRI is often ordered to rule out an intracranial tumor as an etiology; however, MRI is costly and otherwise has a low diagnostic yield for further evaluating asymmetric sensorineural hearing loss. Many otolaryngologists will consistently order MRI to rule out intracranial tumors out of concern for medicolegal reasons, even though a majority of these scans will return negative for a retrocochlear cause of the asymmetric hearing loss.

Vestibular schwannoma, also called acoustic neuroma, is the most common tumor of the cerebellopontine angle (located between the cerebellum and pons) and often presents with unilateral or asymmetric sensorineural hearing loss (Figure 1). Other symptoms may present in association, including imbalance and tinnitus, however, these symptoms are often absent in up to 45% patients diagnosed with acoustic neuroma.

Purpose of Study

The goal of this study was to retrospectively identify the presence of any correlative factors between presenting symptoms and characteristics of asymmetrical sensorineural hearing loss on audiogram, and whether or not retrocochlear pathology was identified on MRI in patients presenting in a private practice setting. Findings from this research may help guide further evaluation of asymmetrical sensorineural hearing loss in the private practice setting and possibly avoid low-yield MRI testing by identifying characteristic criteria. This would, in turn, aim to decrease unnecessary health care costs.

METHODS

After McLaren Oakland institutional review board approval was obtained, the authors (comprised of physicians and medical students) completed a query of Allscripts electronic health records from North Oakland Ear, Nose & Throat Centers. They initially identified a total of 687 patients who underwent MRI for asymmetric hearing loss between
March 2014 and March 2017. A retrospective review of these patient charts was performed. Investigators were supplied with a user-specific login to access the patient charts, and data from each chart was recorded in an excel spreadsheet. Patients were assigned a unique numerical identifier on the spreadsheet to protect their identities. The specific data elements recorded from the history and physical of each chart included:

- Age
- Sex
- Onset of hearing loss (sudden or gradual)
- Presence or absence of tinnitus (unilateral or bilateral)
- Presence or absence of vertigo
- Presence or absence of disequilibrium or imbalance
- Presence or absence of aural fullness or otalgia
- Presence or absence of subjective hearing loss (unilateral or bilateral)
- Audiogram findings (hearing threshold levels for right and left ears at 250 Hz, 500 Hz, 1 kHz, 2 kHz, 3 kHz, 4 kHz, 6 kHz, 8 kHz and speech discrimination scores for right and left ears)
  - Hearing threshold levels = octave frequencies 250-8000 Hz were used\(^{10}\)
  - Hz = hertz, unit of frequency
  - Speech discrimination score = reflects percentage of phonetically balanced words that a patient repeats correctly\(^{10}\)
- MRI results (normal/unremarkable, incidental finding(s), or presence of vestibular schwannoma and size of lesion)

**Inclusion criteria:**

1. Patients with asymmetrical sensorineural hearing loss (based on previous definitions\(^2,4-6\)) on audiogram documenting at least one of the following:
   a. \(\geq 10\) decibel asymmetry across three consecutive frequencies,
   b. \(\geq 15\) dB asymmetry across two consecutive frequencies,
   c. \(\geq 15\) dB asymmetry at 3 kHz,
   d. \(\geq 15\) dB asymmetry between the average of 0.5, 1, 2, and 3 kHz, and/or
   e. \(\geq 15\%\) difference between speech discrimination scores\(^5\)
2. Who subsequently (after audiogram) underwent MRI to evaluate for retrocochlear causes of asymmetrical sensorineural hearing loss.

**Exclusion Criteria:**
1. Patients with recent head trauma or use of chemotherapeutic or ototoxic medications.
2. Remaining patients who did not meet the inclusion criteria.

Data from these patient charts were compiled in a spreadsheet and submitted for statistical analysis to the third author (SJW) at the Michigan State University College of Osteopathic Medicine Statewide Campus System.

**Statistical Analysis:**
Initial analyses assessed whether there were any correlations between the exposure (asymmetrical sensorineural hearing loss) and the outcome (retrocochlear lesion noted on MRI). Also taken into account were factors that could play a part in the relationship between the exposure and outcome. These potential confounding factors included imbalance, vertigo, tinnitus (bilateral or unilateral), the degree of hearing loss, and otalgia. As such, bivariate correlations were examined, (e.g. the hearing thresholds for the right and left ears at the various levels 250Hz, 500Hz, etc.) along with whether a normal or abnormal MRI result was observed. Logistic regression modeling was then performed using the proc logistic function, examining those correlations observed to be significant in the bivariate correlations analyses, in combination with the potential confounding variables (imbalance, vertigo, tinnitus, the degree of hearing loss, and otalgia). All analyses were performed by the third author (SJW) using SPSS Version 24. An alpha cut-off of < 0.05 was considered statistically significant for all analyses.

**RESULTS**
Of the initial 687 study patients, N = 303 (44%) patients met the inclusion criteria for review. Of these 303, 48 patients (15.8%) had abnormal MRI findings (Table 1). Chi-square analysis performed showed no significant association of clinical variables with abnormal MRI (Table 2). Point Biserial Correlation analysis revealed no statistically significant correlations, with the exception of that between AS (Left Ear) 6 kHz and MRI
lesions ($r = -0.115, p = 0.045$) (Table 3). This suggests that there may be an association between experiencing hearing loss at the level of 6 kHz and the presence of retrocochlear lesion noted on MRI. Further analyses utilizing logistic and multinomial logistic regression to calculate the odds ratio (OR) showed that for patients with hearing loss at the 6 kHz level, there was a very slightly lower, statistically significant likelihood of lesions showing up on MRI, OR, 0.984 (95% CI, 0.970-0.998), $p$ value $= 0.0251$.

**DISCUSSION**

One of the cardinal features of acoustic neuroma is the presence of an asymmetric sensorineural hearing loss, and the most frequent presenting symptoms of acoustic neuroma occurring in greater than 95% of patients is hearing loss. According to Hentschel *et al.*, all patients that present with asymmetrical hearing loss or unilateral audiovestibular dysfunction will obtain an MRI, leading to a considerable amount of MRIs with negative findings as the incidence of acoustic neuroma in their screening population varies from 1% to 4.7%. This equates to more than 95% of MRIs resulting negative for acoustic neuroma.

The goal of our retrospective study was to identify the presence of any correlative factors between presenting symptoms and characteristics of asymmetrical sensorineural hearing loss on audiogram, and whether or not retrocochlear pathology was identified on MRI in patients presenting in a private practice setting. Overall, results showed that there appears to be very little difference, if any, in the clinical and/or audiometric findings of those with or without retrocochlear lesions assessed via MRI in private practice setting. One correlation noted in our study was that those with hearing loss at the 6 kHz level showed a slightly lower likelihood of lesions observed on MRI. Further analysis (logistic regression) used to calculate odds ratios demonstrated a slightly lower odds that those with hearing loss at the 6 kHz level were likely to have lesions show up on MRI ($p$ value $= 0.0251$; OR, 0.984; 95% CI, 0.970-0.998). However, this OR approaches very closely to 1, so much so that rounding the higher end of the confidence interval (CI) would actually be 1. This is within a margin of error and suggests that any significance observed is likely the result of statistical noise (i.e. unmeasured confounding factors).
The discussion is then what other data in the literature can help further guide evaluation of asymmetrical sensorineural hearing loss and potentially avoid unnecessary low-yield MRI testing by identifying other characteristic criteria, and thus decreasing health care costs. In reviewing the literature, Saliba et al., proposed the rule of 3,000. They state patients with asymmetrical sensorineural hearing loss of 15 dB or more at the 3 kHz warrant an investigation with MRI and that if the asymmetrical sensorineural hearing loss is less than 15 dB, a biannual audiometric follow-up is recommended. Although we did not find the same results in our study, the above mentioned data may provide otolaryngologists information on ways to reduce the number of negative MRIs ordered.

A limitation to this study is the limited number of our population in a private setting, as we only reviewed N = 303 patients that met our inclusion criteria. A future study with a more generalizable sample (i.e. not limited to the private setting population) could provide improved external validity.

CONCLUSIONS

The purpose of this study was to identify possible correlations between presenting symptoms and characteristics of asymmetrical sensorineural hearing loss on audiogram, and if retrocochlear pathology was observed on MRI in patients within the setting of private practice. A retrospective chart review was conducted; following the statistical analysis of N = 303 patient charts, there was very little difference found between the clinical and/or audiometric findings in patients with or without retrocochlear lesions on MRI. This is with the exception found between those with hearing loss at the 6 kHz level and having a slightly lower likelihood of retrocochlear lesion on MRI findings. Further investigation into potential correlations between findings on clinical exam, audiogram, and MRI will be necessary. These future studies should be conducted on larger sample sizes in both private practice and non-private practice settings in hopes of creating a more concise medical decision-making process for ordering MRI to rule out retrocochlear lesion.
The authors report no external funding source for this study.

The authors declare no conflict of interest.

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REFERENCES


TABLES AND FIGURES

Figure 1

Acoustic Neuroma

MRI brain/internal auditory canals of 19mm enhancing left acoustic neuroma. Image obtained from North Oakland Ear, Nose & Throat Centers P.C.
Table 1
Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Patients: N = 303</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean)</td>
<td>59 years old (SD = 13.6)</td>
</tr>
<tr>
<td>Sex</td>
<td>N = 168 (55.4%) female</td>
</tr>
<tr>
<td></td>
<td>N = 135 (44.6%) male</td>
</tr>
<tr>
<td>Abnormal MRI</td>
<td>N = 48 (15.8%)</td>
</tr>
<tr>
<td>Onset of symptoms</td>
<td>N = 246 (81.2%) gradual</td>
</tr>
<tr>
<td></td>
<td>N = 49 (16.2%) sudden</td>
</tr>
<tr>
<td>Tinnitus</td>
<td>N = 193 (57.1%)</td>
</tr>
<tr>
<td>-0.7% non-specific</td>
<td></td>
</tr>
<tr>
<td>-25.1% B/L</td>
<td></td>
</tr>
<tr>
<td>-16.2% L</td>
<td></td>
</tr>
<tr>
<td>-11.2% R</td>
<td></td>
</tr>
<tr>
<td>-2.3% R &gt; L</td>
<td></td>
</tr>
<tr>
<td>-1.7% L &gt; R</td>
<td></td>
</tr>
<tr>
<td>Vertigo</td>
<td>N = 39 (12.9%)</td>
</tr>
<tr>
<td>Disequilibrium or Imbalance</td>
<td>N = 80 (26.4%)</td>
</tr>
<tr>
<td>Aural Fullness, Otalgia, or Plugged Feeling</td>
<td>N = 118 (38.9%)</td>
</tr>
<tr>
<td>-0.3% non-specific</td>
<td></td>
</tr>
<tr>
<td>-7.3% B/L</td>
<td></td>
</tr>
<tr>
<td>-17.8% L</td>
<td></td>
</tr>
<tr>
<td>-12.2% R</td>
<td></td>
</tr>
<tr>
<td>-0.3% R &gt; L</td>
<td></td>
</tr>
<tr>
<td>-0.3% L &gt; R</td>
<td></td>
</tr>
<tr>
<td>Subjective hearing loss</td>
<td>N = 207 (68.3%)</td>
</tr>
<tr>
<td>-19.1% B/L</td>
<td></td>
</tr>
<tr>
<td>-23.8% L</td>
<td></td>
</tr>
<tr>
<td>-15.2% R</td>
<td></td>
</tr>
<tr>
<td>-3.0% R &gt; L</td>
<td></td>
</tr>
<tr>
<td>-7.3% L &gt; R</td>
<td></td>
</tr>
</tbody>
</table>

B/L = bilateral
L = left
R = right
Table 2
Association of Clinical Variables with Abnormal MRI*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Normal MRI</th>
<th>Abnormal MRI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unilateral tinnitus</td>
<td>70 (23.1%)</td>
<td>15 (4.92%)</td>
<td>p = 0.591</td>
</tr>
<tr>
<td>Bilateral tinnitus</td>
<td>76 (25.1%)</td>
<td>10 (3.30%)</td>
<td>p = 0.206</td>
</tr>
<tr>
<td>Vertigo</td>
<td>30 (9.90%)</td>
<td>9 (2.97%)</td>
<td>p = 0.185</td>
</tr>
<tr>
<td>Disequilibrium or Imbalance</td>
<td>70 (23.1%)</td>
<td>10 (3.30%)</td>
<td>p = 0.340</td>
</tr>
<tr>
<td>Aural fullness, otalgia, or plugged feeling</td>
<td>103 (33.9%)</td>
<td>15 (4.95%)</td>
<td>p = 0.233</td>
</tr>
</tbody>
</table>

*Chi-square analyses performed

Table 3
Association of Audiometric Variables with Abnormal MRI*

<table>
<thead>
<tr>
<th>Variable</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD (Right Ear) 250</td>
<td>0.811</td>
</tr>
<tr>
<td>AD 500</td>
<td>0.580</td>
</tr>
<tr>
<td>AD 1k</td>
<td>0.464</td>
</tr>
<tr>
<td>AD 2k</td>
<td>0.411</td>
</tr>
<tr>
<td>AD 3k</td>
<td>0.251</td>
</tr>
<tr>
<td>AD 4k</td>
<td>0.230</td>
</tr>
<tr>
<td>AD 6k</td>
<td>0.332</td>
</tr>
<tr>
<td>AD 8k</td>
<td>0.279</td>
</tr>
<tr>
<td>AS (Left Ear) 250</td>
<td>0.879</td>
</tr>
<tr>
<td>AS 500</td>
<td>0.838</td>
</tr>
<tr>
<td>AS 1k</td>
<td>0.625</td>
</tr>
<tr>
<td>AS 2k</td>
<td>0.188</td>
</tr>
<tr>
<td>AS 3k</td>
<td>0.075</td>
</tr>
<tr>
<td>AS 4k</td>
<td>0.065</td>
</tr>
<tr>
<td>AS 6k</td>
<td><strong>0.045</strong></td>
</tr>
<tr>
<td>AS 8k</td>
<td>0.079</td>
</tr>
</tbody>
</table>

*Point biserial correlation analyses performed
**Significant at the 0.05 alpha level
Examination of How the Affordable Care Act Influenced Use of Lower-Acuity Emergency Department Services

Joe Haddad DO,1 Kyle Fink DO,2 Katherine Pitus DO 3

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ABSTRACT

HADDAD J, FINK K, PITUS K. Examination of How the Affordable Care Act Influenced Use of Lower-Acuity Emergency Department Services. Spartan Med. Res. J. Vol. 3, No. 2, pp. 123-134, 2018. CONTEXT: The Affordable Care Act (ACA) was implemented to make insurance accessible and reduce healthcare costs. The purpose of this study was to examine for changes in the use of lower-acuity types of Emergency Department (ED) services at two suburban Detroit facilities before, and after implementation of the ACA.

METHODS: A retrospective chart review of patients presenting to the ED at a two-campus suburban hospital system was performed over two 18-month pre- and post-ACA periods. The authors completed a review of electronic health record data and used ICD-9 code and ED visit billing and collections data. Sample patients included those who had received lower-acuity ED care within the two designated time periods. A total of 16 lower-acuity ICD-9 codes were included to gauge pre and post changes in use of ED services.

RESULTS: The authors identified 2,099 patients meeting study criteria during the pre-ACA period and 2,158 patients within the post-ACA period. A subgroup of 166,483 ED patients received care during the pre-ACA time period and 179,879 post-ACA. There was no statistically significant difference between the volume of lower-acuity ED visits during the two analytic periods (i.e., 1.26% seen pre-ACA implementation and 1.20% seen post-ACA). (p = 0.420) Neither did the absolute number of all ED visits significantly change. As could be anticipated, however, the proportion of self-pay patients pre-ACA significantly decreased from 506 (24.1%) to 191 (8.9%) post-ACA. (p < 0.001) Medicaid HMO payments also increased significantly from 824 visits pre-ACA to 1,086 visits post-ACA. (p < 0.001) In addition, Blue Cross coverage increased from 54 visits pre-ACA to 98 visits post-ACA. (p < 0.001) CONCLUSIONS: In summary, our results revealed no significant change in the absolute volume of all ED visits or proportions of lower-acuity ED visits between the pre- and post-ACA periods. As the authors had anticipated, pre and post changes in the number of self-pay patients and those with certain types of insurance coverage were dramatic. The authors conclude that changes in lower-acuity visits to the ED in these study settings had not decreased as envisioned by ACA developers. Future studies with larger longitudinal samples are warranted to more fully investigate the longer-term implications of the ACA on use of ED services.

Keywords: affordable care act, emergency department services, lower-acuity emergency cases, healthcare use choices
INTRODUCTION

An extensive ongoing debate in our country has ensued related to how to make health insurance coverage more readily available for our nation's uninsured population.1-3 In 2010, the Affordable Care Act (ACA) was developed with several overall goals, two of which were to make insurance more accessible to those without coverage and reduce overall healthcare costs.4 The primary motivation for this legislation was a presumption that once the majority of people across the nation had medical insurance, they would be more likely to utilize preventive care and meet their healthcare needs in lower cost primary care settings.2,5,6,7

Similar to several state legislative changes, the ACA legislation has emphasized enhancing the availability and use of primary care services to curb disease processes before they require emergency department (ED) visits, hospital admissions and extensive treatments and procedures.8-10 To date, researchers have found mixed results concerning healthcare service use patterns in select settings and regions of the country. Patient behaviors have been found to vary by type of insurance coverage and the patients' baseline health profiles, with sicker patients tending to take advantage of covered services earlier. Healthcare service use patterns have also been found to vary with the states' current demographics, how the ACA is advertised, and whether the state expands its Medicaid coverage or focuses on expanding its health insurance marketplace.1,2,6,7,11

Various measures have been implemented (e.g., scholarships, loan forgiveness, financial bonuses) to incentivize primary care physicians participating in state-administered Medicaid programs.11 Additionally, healthcare policy makers were hopeful patients who had established relationships with a primary care provider (PCP) would decompress the nation's taxed ED and reduce healthcare costs.2,3,9,12,13

Purpose of Study

The Michigan-based authors aimed to examine what pre- and post-ACA implementation changes may have occurred in the use of lower-acuity ED services in two community-based settings. The authors utilized de-identified electronic health record (EHR) data from an 18-month period before ACA implementation compared to 18 months after implementation. The EHR data were extracted from the hospital billing department
Research Coordinator for the indicated periods from two Ascension Health campuses in the suburban Detroit area.

More specifically, the study questions asked included the following: (1) “To what extent has the ACA influenced relative changes in the volume of lower-acuity ED visits?” (2) “Have overall ED utilization rates changed under the ACA, as measured by absolute number of ED visits?” and (3) “What changes in payer mix (Medicaid, Medicare, uninsured, private pay, etc.) have occurred from before and after implementation of the ACA?” The authors had hypothesized that despite the best intentions of the ACA, the utilization of lower-acuity ED services would still increase despite decreases in the number of uninsured patients.\textsuperscript{2,4,9}

There were also several longer-term goals for this study. First, the authors expected that the area emergency medicine community would be able to use this knowledge to evaluate how the ACA had affected their respective series of Michigan ED facilities. Ideally, national emergency medicine leaders and policy makers would also be able to utilize results from these types of studies to inform their decisions pertaining to future legislation and policy reform initiatives. Additionally, hospital administrations would be able to utilize these types of results to make more strategic financial adjustments for emerging reimbursement trends.

**METHODS**

**Study Design**

This was a retrospective EHR chart review of lower-acuity patients presenting to the ED at St. John Macomb-Oakland Hospital, including both Oakland and Macomb centers, over two 18-month periods. January 1st, 2012 - June 30, 2013 was observed as the pre-ACA implementation period, beginning two years before the implementation of the ACA on January 14, 2014. January 1st, 2015 - June 30, 2016 represented the post-ACA implementation period, beginning approximately one year after initial implementation. De-identified data concerning patients’ insurance coverage payment during both periods were also compared to analyze the reimbursement question. The authors’ institutional review board had approved the study protocol before any data collection began.
Statistical Analyses

Univariate between-group sample subgroup comparisons were completed by the authors’ healthcare system PhD-trained research coordinator (cited in Acknowledgement section) using Chi squared test procedures with all categorical variables. The study analyst conducted all statistical analyses using SPSS version 19.0. He observed a coefficient Alpha p-value of 0.05 or less to indicate statistical significance.

Sample Settings

St. John Macomb Hospital and St. John Oakland Hospital merged in 2007 and became St. John Macomb-Oakland Hospital. As of June 2018, the hospital campuses were renamed within the same system to Ascension Macomb-Oakland Hospital. This healthcare system is located on two campuses, with 535 beds total. St. John Ascension Oakland campus, located in Madison Heights MI, is a 159-bed acute care teaching hospital with approximately 34,000 ED visits per year. St. John Ascension Macomb campus Hospital, located in Warren MI, is a 376-bed facility with approximately 78,000 ED visits per year.

Data collection and processing

De-identified study data were all extracted from the authors’ EHR chart review. The data for study analyses were of several types including ICD-9 diagnosis codes, ED visit billing and collections data concerning eligible patients’ insurance coverage and ED service utilization. Sample patients included all those treated at Ascension Macomb and Oakland Emergency Departments during the identified pre- and post-periods, specifically with, or without, one of the 16 lower-acuity ICD-9 discharge diagnosis codes listed in Table 1. These 16 lower-acuity ICD-9 codes were utilized to gauge changes in use of ED services between lower-acuity and all other patient sample subgroups.

RESULTS

As depicted in Table 2, the authors identified a total of 2,099 (1.3% of total period patients) lower-acuity patients meeting study inclusion criteria during the pre-ACA period and 2,158 (1.2%) lower-acuity patients in the post-ACA period. The total numbers of low acuity ED patients treated during the pre-ACA period was 166,483 and 179,879 low acuity
patients during the post-ACA period. Unfortunately, specific patient-level test results and socio-demographic data were not available in the data sets as extracted.

Although there was certainly a change between the specific ICD-9 and ICD-10 billing codes used during these two analytic periods (ICD-10 took effect October 1, 2015), the analyst found no statistical pre-post differences between the proportions of lower-acuity ED visits ($p = 0.420$). Furthermore, there was no statistical change found in ED utilization patterns as measured by absolute number of lower-acuity visits. In fact, the total number of patients seen during the post-ACA period slightly increased by 13,396. However, we did identify a statistical decrease in the low acuity visits at the Oakland campus by 0.2% ($p = 0.001$) as compared to no statistical change in the Macomb campus low acuity visits. (Table 3) We have since concluded that this may be due to the higher relative proportion of self-pay patients visiting the Oakland campus before the ACA. (Table 4)

As might be expected, the overall proportion of self-pay total sample ED visit patients went down dramatically after implementation of the ACA. (Table 5) The number of self-pay patients before the ACA was 506 (24.1% of eligible sample patients) compared to 191 (8.9%) post-ACA. ($p < 0.001$) Proportions of certain types of insurance coverage, particularly Medicaid HMO and Blue Cross, also went up significantly post-ACA. (both $p < 0.001$) Medicaid HMO coverage increased from 824 visits pre-ACA to 1086 visits post-ACA, and Blue Cross from 54 visits pre to 98 visits post ACA. ($p$ each $< 0.001$)

**DISCUSSION**

These results prompted the authors to question why the overall absolute number of ED visits, including lower-acuity visits, did not significantly decrease after we could confirm that more patients had achieved coverage under the ACA. Clearly, these results are similar to the general findings of several studies that the relationship between health insurance coverage and primary care/ED visit care continues to be very complex.\(^1\,5\,7\,11\) Although our results demonstrate that the overall ED service use of Medicaid HMO and Blue Cross beneficiaries went up significantly under the ACA, many PCP continue to not accept Medicaid patients.\(^7\) Additionally, the co-payments expected for many patients
(including those with unpaid pre-ACA balances) has continued to occur in many primary care office settings.\textsuperscript{1,3,9}

Changes in ICD-9 to ICD-10 diagnostic codes during the total study period may have been an additional factor possibly skewing our results. During the post-ACA period, there were new lower-acuity ICD-10 codes added along with changes in which billing codes were used more frequently. (Table 2) For example, the new set of ICD-10 codes included a diagnosis code 465 “Acute upper respiratory infections of multiple or unspecified sites.” This catch-all diagnosis code was entered for 702 patients in the post-ACA period. (Figure 1 and Table 2) This code wording change appears to have influenced the numbers of some cases away from previous ICD-9 codes. Additionally, there was an increased post-ACA usage of ICD-10 code 79.99 “Unspecified viral infection.” (Table 2) Interestingly, dental pain (ICD-10 code 525.9) did see a significant drop from pre-ACA to post-ACA period, specifically, a 67.5% drop from 664 patients to 216. (Table 2) We have no well-defined reason to account for this dramatic decrease given that there is no requirement or mandate under the ACA to provide coverage for dental services. It is also unclear as to where some patients actually sought dental care during the post-ACA analytic period. There were no new openings of emergent care dental clinics in the immediate area of the two sample campuses, although increased PCP utilization was certainly possible.

**Study Limitations**

The data collected from this convenience sample of patients came from two Michigan suburban healthcare campuses. A larger heterogeneous sample of ED patients (e.g., also including rural and urban settings) may have improved the generalizability of our results to other ED settings.\textsuperscript{3,7} Furthermore, timely access to primary and specialty care services involving Medicaid has still been shown to be inconsistent, leaving many patients with few realistic healthcare alternatives to the ED.\textsuperscript{9,11,13} In addition, since some of the previously-uninsured patients in this sample may have been accustomed to receiving most all of their healthcare services in the ED, perhaps so much so that any such pre-ACA tendencies may take an indeterminate amount of time to change.\textsuperscript{1,6,11,13}

Our extracted study data did indicate the type of insurance used during ED visits, but not regarding any possible deductible amounts. It can be presumed that those
acquiring high-deductible health plans via the ACA marketplace would seek care for lower acuity complaints outside of the ED, making them “better” overall healthcare consumers. Since this study did not stratify those patients from those with higher deductible plans, further investigation with detailed co-payment data and patient socio-demographic data is certainty warranted.

CONCLUSIONS

A primary goal of the ACA was to replace use of ED utilization care for lower-acuity conditions with non-urgent primary care visits. The legislation was partially based on a belief that providing increased insurance coverage would improve patients’ access to primary care, thus substituting lower-acuity ED visits with office-based visits.

Our results revealed no significance changes in the absolute number of lower-acuity ED visits between the pre- and post-ACA analytic periods. Neither was there an overall significant change noted in number of lower-acuity ED visits out of the totality of period ED visits. As might be expected, however, these study results demonstrate a dramatic proportionate decrease in self-pay ED patients as well as substantial increases in certain types of insurance coverage.

We conclude from these results that the utilization of ED services for lower-acuity conditions increased slightly in these two Michigan settings and that the idealized outcomes (i.e., greater primary care coverage for lower-acuity conditions) envisioned by ACA proponents were not readily identified. Further studies with larger longitudinal analytic samples are warranted in these and other settings to more fully gauge the longer-term influence of the ACA on consumption patterns for ED services across the nation.

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REFERENCES


### Table 1

**Selected Study Lower-acuity ICD-9 Codes**

<table>
<thead>
<tr>
<th>Final ICD-9 Diagnosis Code</th>
<th>Final Diagnosis Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>460</td>
<td>Acute nasopharyngitis [common cold]</td>
</tr>
<tr>
<td>461</td>
<td>Acute sinusitis</td>
</tr>
<tr>
<td>461.8</td>
<td>Other acute sinusitis</td>
</tr>
<tr>
<td>461.9</td>
<td>Acute sinusitis, unspecified</td>
</tr>
<tr>
<td>462</td>
<td>Acute pharyngitis</td>
</tr>
<tr>
<td>465</td>
<td>Acute upper respiratory infections of multiple or unspecified sites</td>
</tr>
<tr>
<td>472</td>
<td>Chronic pharyngitis and nasopharyngitis</td>
</tr>
<tr>
<td>472.1</td>
<td>Chronic pharyngitis</td>
</tr>
<tr>
<td>473</td>
<td>Chronic sinusitis</td>
</tr>
<tr>
<td>473.8</td>
<td>Other chronic sinusitis</td>
</tr>
<tr>
<td>473.9</td>
<td>Unspecified sinusitis (chronic)</td>
</tr>
<tr>
<td>487.1</td>
<td>With other respiratory manifestations</td>
</tr>
<tr>
<td>79.99</td>
<td>Unspecified viral infection</td>
</tr>
<tr>
<td>68.1</td>
<td>Medication Refill</td>
</tr>
<tr>
<td>525.9</td>
<td>Dental Pain</td>
</tr>
</tbody>
</table>

### Table 2

**Pre- and Post-ACA Changes in Study ICD-9 Code Claims**

<table>
<thead>
<tr>
<th>ICD Code</th>
<th>Description</th>
<th>number pre-ACA</th>
<th>number post-ACA</th>
<th>Percent change Pre ACA to Post-ACA</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>460</td>
<td>Acute nasopharyngitis [common cold]</td>
<td>4</td>
<td>6</td>
<td>50.0</td>
<td>0.75</td>
</tr>
<tr>
<td>461</td>
<td>Acute sinusitis</td>
<td>2</td>
<td>0</td>
<td>-100.0</td>
<td>0.24</td>
</tr>
<tr>
<td>461.8</td>
<td>Other acute sinusitis</td>
<td>0</td>
<td>7</td>
<td>700.0</td>
<td>&lt;0.02</td>
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<tr>
<td>461.9</td>
<td>Acute sinusitis, unspecified</td>
<td>188</td>
<td>73</td>
<td>-61.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>462</td>
<td>Acute pharyngitis</td>
<td>799</td>
<td>355</td>
<td>-55.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>465</td>
<td>Acute upper respiratory infections of multiple or unspecified sites</td>
<td>0</td>
<td>702</td>
<td>7020.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>472</td>
<td>Chronic pharyngitis and nasopharyngitis</td>
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<td>0</td>
<td>-100.0</td>
<td>0.95</td>
</tr>
<tr>
<td>472.1</td>
<td>Chronic pharyngitis</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
<td>.099</td>
</tr>
<tr>
<td>473</td>
<td>Chronic sinusitis</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
<td>.099</td>
</tr>
<tr>
<td>473.8</td>
<td>Other chronic sinusitis</td>
<td>1</td>
<td>1</td>
<td>0.0</td>
<td>1.0</td>
</tr>
<tr>
<td>473.9</td>
<td>Unspecified sinusitis (chronic)</td>
<td>240</td>
<td>106</td>
<td>-55.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>79.99</td>
<td>Unspecified viral infection</td>
<td>42</td>
<td>596</td>
<td>1319.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>487</td>
<td>Influenza</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
<td>1.0</td>
</tr>
<tr>
<td>68.1</td>
<td>Medication Refill</td>
<td>158</td>
<td>96</td>
<td>-39.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>525.9</td>
<td>Dental Pain</td>
<td>664</td>
<td>216</td>
<td>-67.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>2,099</strong></td>
<td><strong>2,158</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 3
Pre- and Post-ACA Visit Changes by Campus

<table>
<thead>
<tr>
<th></th>
<th>Total ED Visits Pre-ACA</th>
<th>Pre-ACA Low Acuity (%)</th>
<th>Total ED Visits Post-ACA</th>
<th>Post-ACA Low Acuity (%)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oakland</td>
<td>55293</td>
<td>924 (1.6%)</td>
<td>54579</td>
<td>755 (1.4%)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Macomb</td>
<td>111190</td>
<td>1175 (1.2%)</td>
<td>125303</td>
<td>1363 (1.1%)</td>
<td>0.47</td>
</tr>
</tbody>
</table>

*p values are statistically significant*

### Table 4:
Pre- and Post-ACA Changes in Insurance Coverage by Campus

<table>
<thead>
<tr>
<th></th>
<th>Insurance Type</th>
<th>Pre-ACA percent total patients</th>
<th>Post-ACA percent total patients</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oakland Hospital</td>
<td>Medicaid HMO</td>
<td>18.0%</td>
<td>10.1%</td>
<td>0.006</td>
</tr>
<tr>
<td>Macomb Hospital</td>
<td>Medicaid HMO</td>
<td>17.5%</td>
<td>29.5%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Oakland Hospital</td>
<td>Self-Pay</td>
<td>15.8%</td>
<td>7.7%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Macomb Hospital</td>
<td>Self-Pay</td>
<td>12.6%</td>
<td>10.8%</td>
<td>0.003</td>
</tr>
<tr>
<td>Oakland Hospital</td>
<td>Medicare</td>
<td>3.4%</td>
<td>2.3%</td>
<td>0.25</td>
</tr>
<tr>
<td>Macomb Hospital</td>
<td>Medicare</td>
<td>4.6%</td>
<td>3.3%</td>
<td>0.82</td>
</tr>
<tr>
<td>Oakland Hospital</td>
<td>Medicaid</td>
<td>2.8%</td>
<td>3.5%</td>
<td>0.62</td>
</tr>
<tr>
<td>Macomb Hospital</td>
<td>Medicaid</td>
<td>2.1%</td>
<td>2.4%</td>
<td>0.77</td>
</tr>
<tr>
<td>Oakland Hospital</td>
<td>Blue Care Trust</td>
<td>4.2%</td>
<td>4.6%</td>
<td>0.83</td>
</tr>
<tr>
<td>Macomb Hospital</td>
<td>Blue Care Trust</td>
<td>0.2%</td>
<td>0.9%</td>
<td>0.21</td>
</tr>
<tr>
<td>Oakland Hospital</td>
<td>Blue Cross</td>
<td>0.4%</td>
<td>0.4%</td>
<td>0.72</td>
</tr>
<tr>
<td>Macomb Hospital</td>
<td>Blue Cross</td>
<td>0.4%</td>
<td>0.7%</td>
<td>0.11</td>
</tr>
<tr>
<td>Oakland Hospital</td>
<td>Blue Care Network</td>
<td>2.2%</td>
<td>2.4%</td>
<td>0.54</td>
</tr>
<tr>
<td>Macomb Hospital</td>
<td>Blue Care Network</td>
<td>3.3%</td>
<td>6.2%</td>
<td>0.07</td>
</tr>
<tr>
<td>Oakland Hospital</td>
<td>HAP</td>
<td>1.5%</td>
<td>1.5%</td>
<td>0.94</td>
</tr>
<tr>
<td>Macomb Hospital</td>
<td>HAP</td>
<td>4.8%</td>
<td>5.4%</td>
<td>0.46</td>
</tr>
<tr>
<td>Oakland Hospital</td>
<td>Other</td>
<td>3.8%</td>
<td>4.8%</td>
<td>0.62</td>
</tr>
<tr>
<td>Macomb Hospital</td>
<td>Other</td>
<td>2.4%</td>
<td>3.4%</td>
<td>0.68</td>
</tr>
</tbody>
</table>

*p values are statistically significant*
Table 5
Pre- and Post-ACA Overall Changes in Insurance Coverage

<table>
<thead>
<tr>
<th>Insurance Coverage</th>
<th>Pre-ACA (%) (n = 2,099)</th>
<th>Post-ACA (%) (n = 2,158)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-Pay</td>
<td>506 (24.1%)</td>
<td>191 (8.9%)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Medicaid HMO</td>
<td>824 (39.3)</td>
<td>1,086 (50.3)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Medicare</td>
<td>154 (7.3)</td>
<td>135 (6.3)</td>
<td>0.18</td>
</tr>
<tr>
<td>Medicaid</td>
<td>171 (8.1)</td>
<td>207 (9.6)</td>
<td>0.08</td>
</tr>
<tr>
<td>Blue Care Trust</td>
<td>115 (5.5)</td>
<td>131 (6.1)</td>
<td>0.40</td>
</tr>
<tr>
<td>Blue Cross</td>
<td>54 (2.6)</td>
<td>98 (4.5)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Blue Care Network</td>
<td>48 (2.3)</td>
<td>54 (2.5)</td>
<td>0.64</td>
</tr>
<tr>
<td>Health Alliance Plan</td>
<td>32 (0.2)</td>
<td>33 (0.2)</td>
<td>0.47</td>
</tr>
<tr>
<td>Other</td>
<td>107 (5.1)</td>
<td>117 (5.4)</td>
<td>0.63</td>
</tr>
</tbody>
</table>

**Bold** p values are statistically significant

Figure 1
Pre- and Post-ACA Changes in Lower-acuity Code Claims