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WHAT'S INSIDE: ORIGINAL RESEARCH • CASE STUDIES

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TABLE OF CONTENTS

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The Cost of Routine Follow-Up in Total Joint Arthroplasty and the Influence of These Visits on Treatment Plans

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ABSTRACT

Introduction. Many physicians recommend annual or biennial visits after total hip and knee arthroplasty (THA and TKA). This study sought to establish the cost of a post-operative visit to both the health care system and patient and identify if these visits altered patient management.

Methods. A prospective cohort study was conducted using patients presenting for follow-up after THA or TKA from April through December 2016. All surgeries were performed by a single orthopaedic surgeon in Wichita, Kansas. All eligible subjects that met the inclusion criteria received and completed a questionnaire about the personal cost of the visit and their assessment of their function and outcome after total joint arthroplasty. The physician also completed a questionnaire that examined the cost of the visit to the health care system and whether the clinical or radiographic findings altered patient management.

Results. Fifty-six patients participated with an average length of follow-up of 4.5 ± 4.1 years since surgery. The average patient cost was $135.20 ± $190.53 (range, $1.65 - $995.88), and the average visit time for the patient was 3.9 ± 2.9 hours. Eighty percent of patients reported no pain during the clinic encounter, and 11% reported loss of function. Eighty-four percent thought the visit was necessary. Physician time for each visit lasted 12.9 ± 3.7 minutes (range, 10 - 20 minutes). Only 9% of patient encounters resulted in an alteration in patient management. This occurred at an average follow-up time of 3.6 ± 1.8 years after the index procedure. The average cost of each visit to the health care system at large was $117.31 ± 60.53 (range, $93.90 - $428.28).

Conclusions. The findings of this study advise total joint patients and orthopaedic surgeons regarding the cost of routine post-operative appointments and whether these visits alter patient management. The majority of the routine follow-up visits after THA and TKA did not result in an alteration in patient management, but added substantial cost to the health care system. ***Kans J Med 2018;11(3):59-66.***

INTRODUCTION

Total hip (THA) and knee (TKA) arthroplasty are remarkably effective and highly successful surgical treatment options for patients with refractory, end-stage hip and knee arthritis.[1-9] These operations are two of the most common procedures performed by orthopaedic surgeons in the United States. Projections estimate that by the year 2030 the demand for THA will grow 174% to 572,000 per year, while the demand for TKA will grow 673% to 3.48 million procedures annually.[10-11] These numbers are expected to rise as patients live longer and as these procedures are performed more often in younger (55 years of age or less) and more active patients.[12-17]

Even though these procedures have shown great success with high patient satisfaction rates,[18-22] arthroplasty failures continue to remain a challenge. Revision THAs and TKAs are costly to the health care system and the patient's overall well-being.[23-25] Frequently, patients may be asymptomatic before such failure occurs. Timely intervention for patients with asymptomatic complications is beneficial for their long-term health outcomes. Therefore, there is a need for close post-operative monitoring to detect and manage these complications before catastrophic failure arises. Many physicians recommend routine follow-up after total joint procedures.[26] Such follow-up visits, however, can be costly for both patient and the health care system. Given the overall state of American health care at the present and the anticipated rise in the number of joint replacements performed, it is imperative to find a cost-effective model for managing patients after surgery. One possible source of cost containment includes the timing and frequency of follow-up visits to the orthopaedic surgeon and the routine use of radiographs. Additionally, the cost to the patient is as relevant as those incurred by the system. Elimination of waiting and travel time with the associated costs incurred to the patients may improve their satisfaction with care.[27-32]

With the improvements in prosthetic design and materials used in total joint arthroplasty, revision in asymptomatic patients is uncommon within the first seven years post-operatively;[33] therefore, the need for annual or biennial routine follow-up of these patients after total joint replacement is questioned. To our knowledge, explicit written guidelines or standards for long-term THA/TKA follow-up care do not exist, although some general references are noted in the literature.[28,34,35] Because of the lack of specific guidelines and studies in the U.S. for long-term follow-up, the objective of this study was to assess the totality of these costs to the patient, physician, and health care system, and determine whether these routine post-operative clinic visits alter patient management. By making such determinations, potential sources of cost savings for patients and surgeons could be identified and employed, improving the clinical decision-making processes and enhancing patient satisfaction.

METHODS

Institutional review board approval was obtained for this prospective cohort study. Subjects were selected from those patients presenting for follow-up after THA or TKA from April through December 2016 at a single institution by a single board-certified orthopaedic surgeon in Wichita, KS. Inclusion criteria consisted of patients who underwent either THA or TKA for treatment of primary

osteoarthritis and at least 40 years or older at the time of clinic visit. Exclusion criteria consisted of subjects who were less than one year post-operative from THA or TKA, diagnosis of inflammatory arthritis or post-traumatic osteoarthritis, prior revision of THA or TKA, previous joint sepsis, subjects who were being followed at closer intervals than typical protocol for concern of THA or TKA failure, and subjects whose index arthroplasty was not performed by the lead physician.

Each eligible subject that volunteered was informed about the purpose of the study, and received and signed a consent form upon presentation to the orthopaedic clinic for follow-up. Questionnaires (Appendix A) completed by subjects had questions pertaining to the personal cost of the clinic visit. Issues of interest to the researchers were time elapsed since surgery, whether the subject was experiencing pain or loss of function in their joint, how much time the clinic visit took from their day, how many miles they drove to their appointment, total estimated monetary cost of the visit (includes gas, lost wages, co-pays, etc.), whether they had a friend or relative accompanying them and the cost of this visit to that person, and whether the visit was necessary. The mileage was calculated from the travel distance between the subject's home and clinic using Google Maps, and the cost of mileage was calculated using the IRS reimbursement rate for mileage driven for medical purposes of $0.235 per mile.

The lead physician completed a questionnaire (Appendix B) for each eligible subject that participated in this study. The physician questionnaire investigated the type of total joint arthroplasty, time spent on the visit, radiographs or laboratory studies ordered, whether the management plan changed because of the visit, and whether the physician felt the visit was necessary. The cost of the visit to the physician and the health care system, including radiographs, laboratory studies, and cost of the outpatient visit for a given level (1 - 5) for an established patient in a non-facility setting, was determined using the Centers for Medicare & Medicaid Services (CMS) 2015 Physician Fee Schedule, using the non-facility cost and Kansas locality (Table 1). Data collection also included subject demographics information such as sex, age, height, weight, body mass index (BMI), surgical procedure type, date of surgery, and the subject's home address.

Descriptive statistics of the mean, standard deviation, and range were determined using the continuous variables of time elapsed since surgery, subjects' demographics (age, height, weight, BMI), estimated time of the clinic visit, travel distance, estimated average total cost for the patient, physician's clinic visit time, and estimated average total cost for the health care system. Data entry was accomplished using Microsoft Excel 2013 (Microsoft, Redmond, WA).

RESULTS

A total of 58 consecutive subjects participated in the study, of which two were excluded based on the inclusion/exclusion criteria. The population included 27 females (48%) and 29 males (52%; Table 2). The average age was 68 ± 10 years (range, 46 - 86 years) with an average BMI of 33.58 ± 7.73 (range, 15.66 - 52.61). The average length of follow-up since surgery was 4.5 ± 4.1 years (range, 1.0 - 19.3 years). Twenty-one (38%) of the 56 patients had more than one total joint arthroplasty procedure performed. Forty-one (62%) had TKA and 19 (29%) had THA. There were five subjects (8%) with bilateral THA performed and one subject (2%) had bilateral TKA performed.

Table 1. Cost data used in current study.

Code	Description	Cost (USD)*
99211	Level 1 Outpatient Visit, Established Patient	18.62
99212	Level 2 Outpatient Visit, Established Patient	41.03
99213	Level 3 Outpatient Visit, Established Patient	68.71
99214	Level 4 Outpatient Visit, Established Patient	102.17
99215	Level 5 Outpatient Visit, Established Patient	137.99
73510	Radiograph of the hip, unilateral, 2 views	34.05
73520	Radiograph of the hip, bilateral, 2 views	36.40
72170	Radiograph of the pelvis, anterior posterior	25.19
73560	Radiograph of the knee, 1 or 2 views	26.81
73562	Radiograph of the knee, 3 views	31.36
72564	Radiograph of the knee, 4 views	36.58
73565	Radiograph of the knees, bilateral, anterior posterior, weight bearing	30.03
78315	Bone scan, 3 phase	328.21
85025	Complete blood count with differential	10.58
85652	Erythrocyte sedimentation rate, automated	3.68
86140	C-reactive protein	4.70

*CMS/Medicare 2015 data, Kansas locality, non-facility price.

Table 2. Patient demographics.

Total number of patients	Female	27 (48%)
	Male	29 (52%)
Mean age (years)		68 ± 10 (range, 46 - 86)
Height (inches)		66 ± 4 (range, 59 - 74)
Weight (lbs.)		209 ± 52 (range, 97 - 346)
BMI (kg/m^2)		33.58 ± 7.73 (range, 15.66 - 52.61)
Follow-up time (years)		4.5 ± 4.1 (range, 1.0 - 19.3)
Number of patients with >1 joint replacement		21 (38%)
Joint type	Hip	19 (29%)
	Knee	41 (62%)
	Bilateral Hip	5 (8%)
	Bilateral Knee	1 (2%)

Overall, the majority of subjects were satisfied with functional outcomes of their total joint arthroplasty. Forty-five (80%) out of the 56 subjects reported no pain during the clinic encounter. This result indicated improvement (46%) or no change (43%) since their last encounter (Table 3). There were a minority of subjects (11%) that reported loss of function in their total joint arthroplasty; however, only three subjects (5%) stated their function had worsened since their last encounter. There were 29 subjects (52%) who reported improvement in function, and 24 subjects (43%) who reported no change in

function. Despite the time and cost of each encounter, the majority of subjects (84%) thought that the visit was necessary. There were only nine subjects (16%) that thought the visit was unnecessary. For this subgroup of patients, there were two female subjects and seven male subjects who lived an average of 123.9 ± 172.8 miles (range, 9.4 - 430.0 miles) away from the clinical site, and their average follow-up time was 2.3 ± 1.9 years (range, 1.0 - 5.4 years).

Table 3. Summary results.

Patient	Feel pain at vist	Yes	11 (20%)
		No	45 (80%)
	Compare pain vs. previous visit	Improved	26 (46%)
		Worse	6 (11%)
		No change	24 (43%)
	Loss function	Yes	6 (11%)
		No	50 (89%)
	Function vs. previous visit	Improved	29 (52%)
		Worse	3 (5%)
		No change	24 (43%)
	Visit necessary?	Yes	47 (84%)
		No	9 (16%)
	Family member accompany?	Yes	29 (52%)
		No	27 (48%)
	Estimated time taken (hour)		3.9 ± 2.9 (range, 0.5 - 12.0)
	Travel distance (mile)		131.2 ± 158.5 (range, 2.6 - 580.0)
	Estimated average total cost for patient		$135.20 ± $190.53 (range, $165 - $995.88)
Surgeon	Office visit time (minutes)		12.9 ± 3.7 (range, 10 - 20)
	Alter management plan	Yes	5 (9%)
		No	51 (91%)
	Visit necessary?	Yes	5 (9%)
		No	51 (91%)
	Estimated average total cost for health care system		$117.31 ± $60.53 (range, $93.90 - $428.28)

The estimated average cost for the subjects for each encounter was $135.20 ± $190.53 (range, $1.65 - $995.88). Each visit, including travel time, required 3.9 ± 2.9 hours (range, 0.5 - 12.0) of the subjects' time. The distance traveled for each patient varied considerably, resulting in an average travel distance of 131.2 ± 158.5 miles (range, 2.6 - 580.0 miles). There were 29 subjects (52%) who came with a companion to the encounter.

From the physician's perspective, each visit lasted approximately 12.9 ± 3.7 minutes (range, 10 - 20 minutes; Table 3). Out of the 56 subjects, only five (9%) encounters resulted in an alteration in patient management beyond routine follow-up. This occurred an average of 3.6 ± 1.8 years (range, 1.1 - 5.3 years) after the index procedure. One patient received a three-phase bone scan to rule out aseptic loosening. Another patient complained of radiculopathy, and a magnetic resonance imaging (MRI) study of the lumbar spine was ordered. A third patient demonstrated clinically significant quadriceps weakness, and a lower extremity electromyogram and nerve conduction velocity study was ordered. A fourth patient complained of symptomatic patellar osteophytes and global instability. This patient was scheduled for surgery, consisting of open osteophyte excision and polyethylene liner exchange. The final patient had a laboratory panel ordered to rule out periprosthetic infection. For these five subjects, the estimated average cost was $155.16 ± $239.18 (range, $6.96 - $577.29) while the cost of these appointments to the health care system was $261.78 ± $145.60 (range, $100.00 - $428.28), and the average cost of each visit to the health care system at large was $117.31 ± $60.53 (range, $93.90 - $428.28).

DISCUSSION

This study accurately delineated the costs of each clinical encounter from a patient and system perspective using prospectively gathered data from patient and physician questionnaires. The majority of patients were satisfied with the pain and function of their total joint arthroplasty, which is in line with reported data.[36] This study accurately assessed patients' perceptions of the visit in real time instead of relying on patient recall during post-visit follow-up phone calls, and limiting any recall bias. This study assessed whether the encounter resulted in any change in management above and beyond routine follow-up.

Surveys and questionnaires as a method for developing information about clinical practice have been used in many medical specialties.[37,38] Most patients in this study reported by questionnaire they were satisfied with their total joint from a pain and functional standpoint. The majority (91%) of these follow-up visits were not viewed as necessary by the lead surgeon and did not result in an alteration in patient management at an average of 4.5 ± 4.1 years (range 1.0 - 19.3 years) after surgery. These findings contradicted the results of prior studies. Teeny et al.[26] surveyed 682 members of the American Association of Hip and Knee Surgeons and found that the majority (80%) of respondents favored annual or biennial visits for uncomplicated total hip and knee arthroplasties. Furthermore, their study showed an agreement among members that more frequent follow-up may be necessary in the setting previously identified signs of early failure, previous joint sepsis, previous revision surgery, and poor bone quality.

Many physicians recommended scheduling routine post-operative follow-up appointments after primary total joint arthroplasty, even if patients are asymptomatic. The objective of routine outpatient assessment of asymptomatic patients is to evaluate and detect early signs of failure and to guide recommendations for early intervention. Some issues that factor into this decision-making process include implant design, materials, manufacturing methods, implant fixation methods, surgical technique, implant shelf life, presence of bone grafts,[39-43] patient young age,[44-46] activity level,[47,48] patient's

weight,[49] revision arthroplasty,[50-52] poor bone quality,[53] history of joint sepsis,[54-56] compromised immune status, and other underlying disease processes.[45,47] The initial signs of failure detected may be bone loss secondary to osteolysis, resulting in more complex revision procedures with higher risks, higher costs, and less successful outcomes. Some early signs of failed total joint arthroplasty include an increase in pain or a decrease in joint function. Persistent pain and swelling may indicate implant-loosening, wear, or infection; the decline in joint function may cause a limp, stiffness, or instability. Patients who demonstrate these symptoms and signs may require revision joint arthroplasty.

Christensen and Folkmar[57] performed a retrospective chart review study in Denmark to examine whether radiographs at three and twelve-month marks post-operatively resulted in any change in primary elective cementless THA patient management. Their results showed that at three months, only eight (4%) of 216 cases showed any subsidence (all cases were <10 mm), and only one out of the eight patients was treated with crutches while the others received closer follow-up. At 12 months, only two patients (1%) showed stress shielding and were given further follow-up. They concluded that routine radiographs in that first year did not offer any benefit and would only be warranted when the patient presented with a specific complaint regarding their total joint. Hacking et al.[33] performed a prospective analysis of 110 THAs over a four-year period, and they found that only four (3.6%) of the 110 cases were for asymptomatic revisions in the first seven years after primary THA. Other studies supported "no follow-up" until several years after primary THA.[58,59] The findings in the present study corroborated these results. In the present study, all patients received a clinical and radiographic examination during their encounter, but rarely (9%) did this lead to an alteration in care. It is no doubt that detection of silent but potentially significant problems in total joint arthroplasty may be enhanced by regular, periodic follow-up, which would allow the impending failure to be detected at an earlier stage, thus reduce the increasing health care costs and burdens associated with revision THA and TKA. The current practice of routine follow-up of asymptomatic THA or TKA, however, may be excessive, costly, and unnecessary, and a less resource-intensive review method may be more appropriate.

Interestingly, our results indicated that 84% of total joint arthroplasty patients preferred routine follow-up. This result contradicted reports from a study performed by Sethuraman et al,[28] which looked at 100 asymptomatic or minimally symptomatic total joint arthroplasty patients with two or more years prior between June 1998 and October 1998. Their results showed that nearly half of their patients preferred to avoid the routine follow-up secondary to lost time and wages, and patient-provider telephone care was preferred. One possible explanation for this disparity is due to pre-operative patient education. Pre-operatively, most patients are informed, either by their surgeon or the internet, that they will need routine annual or biennial follow-up to ensure they are not developing any post-operative complications. Many of these patients, including those without symptoms, may feel these visits are crucial in preventing catastrophic problems with their total joint. Educating patients regarding early signs and symptoms of total joint arthroplasty failure is crucial if physicians plan to eliminate early routine follow-up visits in the first few years after surgery when patients are less likely to develop these complications. Patient education, such as the benefit of proper diet, acceptable levels of post-arthroplasty exercise, and smoking cessation, should be emphasized. Tobacco has been shown to hinder bone healing. Alcohol consumption (beer, liquor, or wine) of three or more units per day will have consequential effects on bone health, leading to lower bone mineral density when compared with more moderate drinking.[60] Education on avoidance of preventable falls also has a major impact on reducing further periprosthetic and fragility fractures, especially in patients with osteoporosis who often experience muscle weakness, postural deformity, and poor balance.[61] Patients who undergo tailored exercises and intervention have a decrease in fall rate in the community.[62] These measures with appropriate patient education could reduce the need for routine early follow-up after a total joint arthroplasty.

The cost to the patient is as relevant as those incurred by the health care system. Elimination of waiting and travel time with the associated costs incurred to the patients may improve their satisfaction with care.[29-32] Sethuraman et al.[28] reported their patient population could have saved wages averaging $135 for each clinic visit in Philadelphia, PA in 1998. This study also determined a similar average cost to the patient. In the present study, the average cost was $135.20 ± $190.53 (range, $1.65 - $995.88). In the Midwest, such variation is not unexpected when one considers the geographical area orthopaedic surgeons may serve.

When factoring in the driving time and distance along with lost wages, it makes it easier to recognize how such a visit may prove more expensive for a patient living further away than for another residing in the same zip code. For this reason, telemedicine may become an option for the future. Patients could have x-rays taken at their local hospital or primary care provider's office and have the imaging sent to their surgeon for review, followed by a telemedicine encounter to discuss how the patient's total joint is performing. However, telemedicine is only a virtual interaction. The encounter would be missing the physical examination component, which is an important part of the evaluation process. Without it, there exists the possibility that certain issues could be missed. To our knowledge, no studies have been performed comparing the efficacy of telemedicine interactions compared to traditional patient encounters concerning detection of complications after total hip or knee arthroplasty. Such research, however, could represent an area of future study for follow-up of total hip and knee arthroplasty patients.

As health care costs increase, more emphasis has been placed on cost containment. The numbers generated in our study represent one possible source of savings to the health care system. Bolz et al.[27] used a decision-analytic Markov model to compare the costs and health outcomes of three follow-up strategies after primary total joint arthroplasty and demonstrated that without routine follow-up for the first seven years after surgery, there would be a total

savings to the system of $11.9 million and gains of between 1.8 to 8.8 quality-adjusted life years for patients. However, it is important to temper the goal of cost savings by balancing with it a need to provide satisfactory patient care. Identifying pre-operatively which patients may wish to have routine post-operative visits and benefit from them versus those that would prefer less frequent follow-up intervals, may allow for a strategy in which health care costs are decreased while concomitantly increasing patient satisfaction.

Several concerns may be raised regarding the validity of our model and applying our results to the management of routine follow-up visits after total joint procedures. The most significant limitation in this study was small sample size, and the patients were drawn only from one local physician. This prevented application of tests of significance due to insufficient power. The low number of subjects participating was unavoidable because the office staff of the lead physician experienced a high turnover rate during the data collection period. Repeating this study with a larger number of enrollees would be beneficial, thus making the data more reliable for a treatment analysis. This would be beneficial to practitioners deciding on how to manage post-operative follow-up after total joint arthroplasty. Another limitation was that the physician reviewing the prospective group was not blinded to the purpose of the study. This situation could introduce a collection bias that might underestimate the importance of routine post-operative follow-up. Another weakness was that the cost determinations were only estimates based on Medicare reimbursement rates for billed CPT codes. The present study did not collect data regarding patients' insurance policies. It was likely that several patients had insurance other than Medicare that paid for their health care. Our estimated costs may not reflect the true amount the facility billed, nor what was paid by the insurer. The cost to the patient was only an estimate based on patients' travel distance to and from the clinic and potential lost wages of both themselves and their companions.

Additionally, this study identified a discrepancy between patients and the physician regarding the usefulness of each post-operative visit. However, the questionnaires did not explore the rationale behind these beliefs. Examining these thoughts could identify the etiology behind the difference and provide physicians with a better understanding of their patients' psyches, thus improving the doctor-patient relationship. Despite these limitations, our data were valid. Further research using a larger study population with multiple surgeons and employing a cost-effectiveness model is needed, and subjects should be followed prospectively at each post-operative visit to support and expand upon our findings further.

CONCLUSION

In summary, this study illustrated that the majority of post-operative follow-up visits, especially for those asymptomatic patients, did not result in an alteration in patient management, but added substantial cost to the health-care system. Future studies are needed to determine, fully and accurately, the cost-effectiveness of these visits and how many patients must be seen routinely to prevent total joint failure.

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Keywords: arthroplasty, follow-up care, survey, cost of illness

APPENDIX A: QUESTIONNAIRE FOR SUBJECTS

Routine Follow-Up in Total Joint Arthroplasty Study Subject ID: _____

Questionnaire for Patients

1	When was your most recent joint replacement (the date)?			
2	What type of surgery did you have?	☐ Total **hip** replacement	☐ Total **knee** replacement	
3	Are you experiencing any pain in your new joint now?	☐ Yes	☐ No	
4	Compare to the last visit, your pain is…	☐ Improved	☐ Worse	☐ No change
5	Are you experiencing any loss of function in your new joint?	☐ Yes	☐ No	
6	Compare to the last visit, function in your new joint is…	☐ Improved	☐ Worse	☐ No change
7	Estimate how much time from your day is this appointment taking (including driving and office time)?			
8	What is your home address? (this information only used for calculating mileage cost)			
9	Estimate how many miles round-trip is this office visit for you?			
10	Estimate what is the cost of this visit to you (co-pay, lost wages, cost of gas, etc.)?			
11	Do you have a family member or friend accompanying you to the office today?	☐ Yes	☐ No	
12	Estimate what is the cost of this visit to your family member or friend (lost wages, etc.)?			
13	Do you feel this visit is necessary?	☐ Yes	☐ No	

APPENDIX B: PHYSICIAN STUDY QUESTIONNAIRE

Routine Follow-Up in Total Joint Arthroplasty Study Subject ID: _____

Physician Study Questionnaire

1	Gender (M/F)	☐ Male	☐ Female
2	Age (optional if age > 89)		
3	Height (inches)		
4	Weight (lbs)		
5	Was the patient seen for any of the following reasons? If yes, please check one (patient to be excluded from study).	☐ Patients who are less than one year out from total hip or knee arthroplasty ☐ History of inflammatory arthritis ☐ History of post-traumatic osteoarthritis ☐ Previous revision total hip or knee arthroplasty ☐ Previous joint sepsis ☐ Patients who are being followed at closer intervals than typical protocol for concern of total hip or knee failure ☐ none of the above	
6	What type of implant was used?	☐ Hip	☐ Knee
		☐ Cemented	☐ Non - cemented
		☐ Metal-on-metal ☐ Metal-on-polyethylene ☐ Ceramic-on-ceramic ☐ Ceramic-on-polyethylene	
7	Date of primary surgery		
8	How much time did the office visit take (minutes)?		
9	Office Visit Level (Establish Patient, Non-Facility Setting)	☐ Level 1 (99211) ☐ Level 2 (99212) ☐ Level 3 (99213) ☐ Level 4 (99214) ☐ Level 5 (99215)	
10	Type of radiographs ordered? (Non-Facility Setting)	☐ AP pelvis (72170) ☐ Hip, unilateral, 2 view (73510) ☐ Hip, bilateral, 2 view (73520) ☐ Knee, 1 or 2 views (73560) ☐ Knee, 3 views (73562) ☐ Knee, 4 views (73564) ☐ AP, bilateral knees, weight bearing (73565) ☐ None	
11	Type of lab ordered?	☐ Complete blood count with differential (85025) ☐ Erythrocyte sedimentation rate, automated (85652) ☐ C-reactive protein (86140) ☐ None	
12	Did this office visit or the outcome of these tests alter the patient's management plan?	☐ Yes	☐ No
13	Do you feel this visit was necessary?	☐ Yes	☐ No

KANSAS JOURNAL of MEDICINE

Characteristics of Laboratory Confirmed Ethylene Glycol and Methanol Exposures Reported to a Regional Poison Control Center

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ABSTRACT

Introduction. Ethylene glycol (EG) and methanol (MET) exposures are rare but can cause significant morbidity and mortality. Though frequently treated similarly, EG and MET exposures have characteristics that are not well differentiated in the literature. We sought to describe the clinical characteristics of EG and MET exposures, confirmed with quantitative serum levels.

Methods. An IRB-approved retrospective review of the University of Kansas Health System Poison Control Center database from July 2005 to July 2015 identified all EG/MET exposures evaluated at a health care facility. Initial measurements were EG/MET levels, serum pH, serum creatinine, anion gap, serum ethanol level, max anion gap, max osmolar gap, therapy performed (hemodialysis, fomepizole, ethanol) and death.

Results. The search identified 75 cases, with 59 cases having only detectable EG levels and 15 cases having only detectable MET levels. The average EG level was 126 mg/dL (range 5 - 834). The average detectable methanol level was 78 mg/dL (range 5 - 396). The average maximum anion gap of the EG positive group was 20 mEq/L (range 8 - 35). The average maximum anion gap of the MET positive group was 14 mEq/L (range 6 - 34). One death was reported in the EG positive group, with an initial level of 266 mg/dL.

Conclusions. In this study of EG/MET exposures, EG exposures were more common than MET exposures, but they had similar demographics, laboratory findings, and interventions. Continued studies are warranted to characterize these uncommon exposures further. ***Kans J Med 2018;11(3):67-69.***

INTRODUCTION

Ethylene glycol (EG) and methanol (MET) are toxic alcohols that consistently account for intentional and unintentional poisonings in many countries across the world.[1] Ethylene glycol is found in many household agents such as antifreeze and deicing solution. It is a colorless, odorless, and sweet tasting liquid. Methanol is found in household and industrial agents such as windshield washer fluid. Both toxic alcohols have been reported in cases of accidental ingestion, as well as suicide. Patients that overdose on EG or MET accumulate toxic levels of glycolic acid and formate, respectively due to metabolism of the parent compound.

Ethylene glycol is first converted into glycolaldehyde by the enzyme alcohol dehydrogenase, then rapidly into glycolic acid. The conversion of glycolic acid to oxalic acid is slow; therefore, glycolic acid can accumulate to toxic levels.[2] Toxic effects include convulsions, coma, metabolic acidosis, hypocalcemia and renal failure. Symptoms can occur within 30 minutes of ingestion due to how quickly EG is absorbed by the stomach.[3] Treatment of EG overdose is based on counteracting the buildup of glycolic acid which is accomplished by targeting and inhibiting alcohol dehydrogenase through intravenous fomepizole or ethanol. The American Academy of Clinical Toxicology (AACT) recommends a minimum treatment threshold of 20 mg/dL of ethylene glycol.[2] Hemodialysis is indicated if severe acidemia or end organ injury is present.[3]

Methanol is absorbed in the gastrointestinal tract and metabolized in the liver to formaldehyde by alcohol dehydrogenase, which in turn is converted to formate that can accumulate to toxic levels.[3] Toxic effects include severe abdominal pain, retinal toxicity, acidosis, convulsions and coma. Severe symptoms of MET poisoning occur hours later compared to minutes in EG poisoning. The half-life of MET is 43 hours, so elective hemodialysis often is necessary to enhance elimination or reduce duration of therapy.[4] Treatment of MET overdose is based on counteracting the buildup of formate. Similar to treating EG exposures, targeting and inhibiting alcohol dehydrogenase is the foundation for treating MET exposures and the AACT recommends a minimum treatment threshold of 20 mg/dL of methanol.[2] Hemodialysis may be required if acidemia or end organ injury is present.

Once metabolism of EG or MET has taken place, patients will present with a high anion gap metabolic acidosis and systemic effects based on the toxin.[5] Prior to metabolism, an increase osmolar gap may be present, but this disappears with evolution of the anion gap acidosis.

Along with clinical history and presentation, these laboratory findings guide the management and treatment of EG and MET overdose. Distinguishing the etiology of the overdose can be done by measuring serum levels of EG or MET and their breakdown products. However, this can take several days, when these life-threatening exposures require immediate medical attention.[6]

The literature on the difference in characteristics between EG and MET exposures remains limited. While the accumulation of toxic metabolites in each exposure is different, the clinical presentation is similar.[1] Serum chemistry often reveals a high anion gap metabolic acidosis and widened anion and osmolar gap for both exposures.[5] Our study objective was to describe the clinical characteristics of EG and MET exposures.

METHODS

An IRB-approved retrospective review of all cases of ethylene glycol or methanol exposure greater than a mouthful in humans reported to the University of Kansas Health System Poison Control Center (PCC) from July 1, 2005 to July 1, 2015 were identified using the American Association of Poison Control Centers (AAPCC) codes for ethylene glycol and methanol.[7] Data were anonymized and de-identified prior to analysis. The PCC receives calls from the public and health care facilities for the entire state of Kansas. All cases that were confirmed as non-exposures, exposure via dermal, and exposures via ocular were excluded as serum levels of EG/MET would not be observed with these types of exposures.

The following characteristics were extracted from the data: age, sex, month of exposure, exposed substance (EG, MET or both), reason for exposure, admission rate, duration of PCC follow up, initial EG/MET levels, serum pH, serum creatinine, anion gap, serum ethanol level, max anion gap, max osmolar gap, therapy performed (hemodialysis, fomepizole, ethanol) and death.

RESULTS

The search identified 75 cases, with 59 cases (79%) having only detectable EG levels and 15 cases (20%) having only detectable MET levels. There was one case (1%) with simultaneously positive EG and MET levels; a reported methanol exposure found to have an EG level of 5 mg/dL and a MET level of 109 mg/dL. The average EG level was 126 mg/dL (range 5 - 834). The average detectable methanol level was 78 mg/dL (range 5 - 396). Table 1 shows the patient demographics. Table 2 characterizes patients with serum positive EG and serum positive MET. One death was reported in the EG positive group, with an initial level of 266 mg/dL.

Table 1. Patient demographics.

	EG positive	MET positive
Total patients	59	15
Mean age (years)	33 [1.6 - 71]	31 [1.2 - 66]
Sex (Male/Female)	37/22	11/4
Intentional ingestion	50	13
Admitted to hospital	57	13

Table 2. Characteristics of patients with serum positive EG and serum positive MET.

	EG positive	MET positive
Mean initial pH	7.28 [6.6 - 7.52]	7.31 [7.09 - 7.52]
Mean initial creatinine (mg/dL)	1.24 [0.3 - 4.9]	0.98 [0.62 - 1.9]
Mean Max Anion gap (mEq/L)	20 [8 - 35]	14 [6 - 34]
Mean Max Osmolar gap (mOsm/kg)	38 [(-) 10 - 129]	38 [3 - 142]
Fomepizole administered	52	11
Ethanol administered	3	3
Hemodialysis performed	25	3

DISCUSSION

In this study of EG/MET exposures, EG exposures were more common than MET exposures, but they had similar demographics, laboratory findings and interventions. The initial diagnosis of EG or MET poisoning is difficult due to the similar clinical presentation of these exposures and mental status of patients at the time of admission. While measurements of serum levels of EG or MET can distinguish these two toxic alcohols, analysis can take several days, which is problematic for many emergency departments and hospitals.[6]

Both EG and MET are readily accessible, frequently found in automotive antifreeze, de-icing solution, windshield wiper fluid and other industrial products.[8] EG and MET can be utilized as a substitute for alcohol or, more frequently, as an intentional ingestion in suicide attempts. The majority of cases from our study were intentional ingestions.

The mean maximum anion gap for serum positive ethylene glycol patients was greater than serum positive methanol patients. There is not a clear explanation for this finding. It is possible in this study that the presentation of serum positive ethylene glycol patients was delayed, resulting in more time for development of an anion gap. Although patients with EG exposure had a more severe anion gap than patients with MET exposure, fomepizole was the mainstay treatment for both exposures.

EG and MET exposures presented with similar systemic effects and similar serum chemistries. Management for both EG and MET is based on preventing the buildup of toxic metabolites. Fomepizole is the most widely used "antidote" for EG and MET exposures.[2] It works by inhibiting alcohol dehydrogenase, thus preventing metabolism of both EG and MET. Administered intravenously, fomepizole induces its own metabolism, so after the fourth 10 mg/kg dose, the dose should increase to 15 mg/kg every 12 hours. Previously, ethanol was used to treat these exposures. However, due to difficulty in dosing and complications, it has fallen out of favor.[9]

In this study, fomepizole was used ten times more than ethanol. Hemodialysis is the treatment of choice for EG or MET toxicity for which the toxic metabolites have already accumulated and caused acidemia or end organ injury.[3] Hemodialysis also will remove the parent compound.

This study had several limitations. It was a retrospective study of previously collected poison center data and key information may not have been documented. In addition, there is the possibility of reporting bias as not all cases of EG/MET exposures may have been reported to the poison center. Finally, the sample size of this study was small and as it is the experience of a single poison control center, its external validity may be limited.

The standard evaluation for exposures to methanol and ethylene glycol is not delineated clearly in the medical literature. Most authors recommend evaluation with serum levels in cases of methanol and ethylene glycol exposure.[10] These serum levels can be important in deciding whether to implement potentially expensive treatment, such as dialysis. However, patients with EG or MET poisonings are in a life-threatening situation that requires early intervention based on clinical judgment. Therefore, patients presenting with clinical symptoms of either toxic alcohol poisoning should be treated immediately, with less emphasis on distinguishing whether the etiology is due to EG or MET. Continued studies are warranted to characterize these uncommon exposures further.

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Keywords: ethylene glycol, methanol, poison control centers, Kansas

KANSAS JOURNAL of MEDICINE

Exploring the Impact of Group Size on Medical Students' Perception of Learning and Professional Development During Clinical Rotations

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ABSTRACT

Introduction. Research assessing the size of learning groups in medical education and how that affects the learner's experience is limited. The main goals of the study were to (1) assess the effect of varying group size on medical students' subjective experiences during clinical years. We hypothesized that students in smaller groups were more likely to have better experiences during clinical rotation than those in larger groups, and (2) determine if medical students have desirable experiences working with other medical learners (fellows, residents, osteopathic students, physician assistants, and nurse practitioners) during clinical rotations.

Methods. The study utilized a mixed method approach where 153 medical students in their clinical years were asked to complete a 10-item survey. A linear-by-linear association test of trend and Mann-Whitney U test were used to evaluate the students' quantitative data. A multidisciplinary team used an immersion-crystallization approach to analyze the content of the students' qualitative data.

Results. There was a 90% (137/153) response rate. Most students (80%) reported desirable experiences during clinical rotations because of supportive learning environments, engaging preceptors, willingness of residents to teach, as well as the opportunity to participate in patient care. There were significant differences in students' perceived clinical experiences as a function of group size, where groups of two students were preferable over groups of four or more.

Conclusions. Varying group size appears to affect students' clinical experiences. ***Kans J Med 2018;11(3):70-75.***

INTRODUCTION

Clinical rotations play a vital role in medical education. Clinical rotations give clinical learners (fellows, residents, medical students, physician assistants, and nurse practitioner students) exposure to a wide variety of specialties, while interacting with higher-level learners and attending physicians. Group educational experiences vary within clinical rotations with opportunities including bedside rounds, self-study, didactics, and problem-based learning.

Learner's experience improves with the quality of the educator's communication skills and clinical expertise.[1] Those factors also can play a role in a learner's career choice. Clinical learners rate clinical rotations higher when they are well organized, well supervised, the learner is integrated fully into the experience, and there is opportunity to improve clinical skills.[1,2]

In contrast, literature from nursing education shows students placed in "unhealthy" environments that consist of lack of respect, trust, and support are likely to have increased psychosocial risks that often lead to reduced satisfaction in their clinical experiences.[3] Additionally, despite evidence showing that learners appreciate and prefer learning by way of bedside rounds, this activity can be limited when the number of learners in a group is large.[4] Interestingly, learners are not the only ones who benefit from bedside rounds, as the patient experience improves as well.[5] The patient perceives that more compassionate care is provided in this setting.

To provide learners with ample patient exposure, bedside teaching can include a large number of learners. Understandably, medical students could feel lost in a large group and may experience a lack of support or even disrespect if attention is not directed toward them. Conceivably, this could happen even when the attending is doing his or her best to create a healthy learning environment.

Logically, most attending physicians want to provide adequate oversight of their learners in addition to trying to make them feel like they are an important part of the team. At a basic level, accessibility to the attending is important to ensure the students feel supported; however, the availability of an attending to students can be misperceived. Physicians believe they are more accessible to their students than the learners think they are.[6] If the attending feels like they are available, but the student does not, this could create an environment where the student feels neglected and be the reason why twice as many students think that first and second year residents are better teachers than physicians.[6]

There is very little research assessing the size of clinical learning groups in medical education and how that affects the learner's experience. Rezmer and colleagues[7] have demonstrated there is no difference in the medical students' experiences during a resuscitation simulation learning module with groups ranging in size from two, three, or four. The current study seeks to find if there is a difference in the medical students' clinical experience based on learner group size. For the purposes of this study, we defined "clinical experience" as students' perception of clinical proficiency, professional development, and access to attending during clinical rotations. Specifically, the study seeks to gather more information related to the following questions:

1. Are there differences among medical students' experiences working in groups ranging from two, three, or four? We hypothesized that medical students (MS) in larger groups were less likely to have desirable clinical experiences than students in smaller groups.
2. Does group size of clinical learners (fellows, residents, osteopathic students, physician assistants, and nurse practitioners) affect medical students' perception of clinical proficiency, professional development, and access to attending during clinical rotations?
3. Do medical students have better clinical experiences when working with other clinical learners? If so, why?

METHODS

Study Design

This non-experimental, cross-sectional study relied on third (MS3) and fourth year medical students (MS4) to complete a survey to assess their experiences working with other clinical learners during clinical rotations. The convenience sample of third and fourth year medical students was used because the students were in their clinical years at a local medical school. The study utilized a mixed method approach[8,9] (integrating both qualitative and quantitative questions) to collect, analyze, and interpret the data. The use of qualitative design, specifically, provided the researchers with an opportunity to develop an in-depth understanding into factors that improve students' clinical experiences. The University of Kansas School of Medicine-Wichita IRB granted an exemption for the study.

Study Instrument

The data used for this study are part of a larger study that examined MS perception of clinical proficiency, professional development, and comfortability working with other clinical learners during clinical years. During our literature search, we were not able to find a previously validated survey instrument that met our needs. Therefore, we developed a 10-item survey questionnaire (see Appendix A) to measure the participants' perception of working in groups during clinical rotations. First, the items were created based on the goal of the study. The generated questions were reviewed by the local associate dean for medical student curriculum and the director of the family medicine clerkship, who have experience in MS clinical clerkship development and implementation, to ensure that the questions accurately assessed the constructs identified in the study. A group of MS3s vetted the questionnaire to ensure that the items had face validity. The students who vetted the questionnaire did not participate in the actual study. Medical students in their clinical years (N = 153) were requested to complete the survey between December 2016 and May 2017. The authors used a paper-and-pencil approach to collect the data.

Statistical Analyses

A linear-by-linear association test of trend was calculated to determine if the students' experiences with clinical rotations related to their group size. Follow-up pairwise comparisons were conducted to evaluate differences among the proportions from the association test. The Mann-Whitney U test also was conducted to evaluate whether students' perception of clinical proficiency, professional development, and access to attending differed based on their clinical experiences during rotations. A *priori* analysis was used to power the study based on asymptotic relative efficiency adjustment of 0.988 for nonparametric Mann Whitney U test.[8] Assuming a criterion value of $\alpha = .05$, $d = .05$, adjusted N = 144 (137/0.988), the priori statistical power was 0.98.

A multidisciplinary team utilized an immersion-crystallization approach[9-12] to analyze the qualitative data. The team comprised of a community psychologist (SO-D), a family physician (KG), and a family physician and an associate dean for curriculum (SM). An immersion-crystallization is a dual process where researchers examine collected data in details, momentarily suspend the immersion process to reflect on the data, and attempt to identify observed themes during the immersion process.[9-11]

RESULTS

Quantitative Results

Of the 153 total medical students in the third and fourth year classes on a local campus, data were collected from 137, an 89.5% response rate. Of the 135 respondents who provided their sex, 54.1% were men and 45.9% were women. The majority of the respondents (77.4%) were Caucasian (Table 1). Eighty percent (110) of the students reported that they had desirable experiences during their clinical rotations and provided several reasons (these are discussed later, under the qualitative results section). The linear-by-linear association test showed a statistical association between the students' clinical experiences and group size (χ^2 (134) = 6.1, p = .014; Table 2). The proportion of students with group size of two, three, or four who had desirable clinical experiences was .87, .70, and .67 respectively.

Table 1. Demographic profile of participants (n = 137).

Demographic of Participants	Measure
Sex, *no.* (%)	
Male	73 (54.1)
Female	62 (45.9)
Missing	2
Age	
Mean (SD)	27.6 (2.4)
Range	25 to 38 years
Missing	2
Ethnicity, *no.* (%)	
African American	6 (5.4)
Caucasian	103 (77.4)
Hispanic/Latino	7 (5.3)
Asian	10 (5.7)
Bi-racial	5 (3.8)
Other	2 (1.5)
Missing	4
Year in medical school, *no.* (%)	
MS 3	73 (53.3)
MS 4	64 (46.7)

Table 2. Results of linear-by-linear test and descriptive statistics for medical students working in groups.

	Clinical Experience		
Group Size	Desirable	Undesirable	Total
Group size = 2			
Count	73	11	84
Expected count	67.2	16.8	84.0
Percentage within group size	86.9	13.1	100.0
Group size = 3			
Count	21	9	30
Expected count	24.0	6.0	30.0
Percentage within group size	70.0	30.0	100.0
Group size ≥ 4			
Count	14	7	21
Expected count	16.8	4.2[a]	21.0
Percentage within group size	66.7	33.3	100.0
Total			
Count	108	27	135
Expected count	108.0	27.0	135.0
Percentage within group size	80.0	20.0	100.0

Note: $\chi^2 = 6.1$, $p = 0.14$; $df = 1$

[a]Has expected count of less than 5. The minimum expected count is 4.20.

Follow-up pairwise comparisons were conducted to evaluate the differences among the proportions (Table 3) with the Holm sequential Bonferroni method to control for Type I error at the 0.05 level across all three comparisons. The only significant pairwise difference was between group sizes of two and four. The probability of a student having desirable clinical experience was 1.30 times (.87/.67) more likely when s/he was in a group size of two learners as opposed to group size of four.

Table 3. Results for the pairwise comparisons using the Holm's Sequential Bonferroni method.

Comparison	Pearson Chi-Square	*p* value (Alpha)	Cramer's *V*
Group size = 2 vs. Group size = 4	4.80*	.028 (0.50)	0.22
Group size = 2 vs. Group size = 3	4.33	0.37 (0.25)	0.20
Group size = 3 vs. Group size = 4	0.06	.80 (.017)	0.35

*p value ≤ alpha

As shown in Table 4, working in groups did not have an effect on students' perceptions of their clinical proficiency, professional development, and access to attending physicians at the end of the rotation. However, when median scores were analyzed as a function of students' level of clinical experiences, students who reported undesirable experiences felt working with other clinical learners (1) interfered with their clinical proficiency ($z = -3.77$, $p < .001$; median of desirable = 3.0, median of undesirable = 2.0), and (2) negatively affected their access to the attending ($z = -3.99$, $p < .001$; median of desirable = 2.0, median of undesirable = 1.0).

Qualitative Results

Medical students who had desirable clinical experiences. Of the 137 respondents, 110 (80%) reported to have had desirable clinical experiences during their clinical rotations. Four interconnected themes emerged from their data analyses as reasons for better clinical rotations: safe and supportive learning environments, hands-on experiences, engaging preceptors, and willingness of residents to help. Each of these themes is discussed in detail in the subsequent sections.

Safe and supportive learning environment. Of the 110 students who reported to have had better clinical experiences, 38 (35%) credited supportive learning environments. MS A stated "great working environment and lots of support from fellow students and residents." This sentiment was shared by MS B who explained "supportive learning environment, and flexibility to learn in different settings were very helpful." Other students felt that working with other clinical learners improved their clinical experiences because of shared responsibilities. MS C wrote "having other learners there provided additional point of view to learn from." Likewise, working in an environment where students felt comfortable to ask questions improved clinical experiences. MS D explained "I felt comfortable asking questions, safe learning environment." MS E's response typified a safe learning environment where students can ask questions: "I was able to ask questions and fully participate."

Hands-on experiences. Thirty-two percent (35 of 110) of the participants indicated that they had desirable clinical experiences because they were involved in patient care during their clinical rotation. MS F explained "it was very hands-on, and I learned a lot." This sentiment was echoed by MS G: "lots of hands-on experiences." Some participants also indicated that working one-on-one with preceptors was a great experience. MS H wrote "I worked with a physician one-on-one and got a great experience."

Engaging preceptors. Nineteen percent (21 of 110) of the participants who had desirable clinical experiences expressed that their interaction with the attending physicians made their experiences worthwhile. Specifically, it was the eagerness of the attending to educate the students that helped the latter enjoy their clinical experiences. MS I wrote "the attending was very good at teaching and engaging all the students and residents." MS J also made a similar observation: "attending took time to teach as well as discuss cases and answer questions."

Willingness of residents to help. Fourteen percent (15 of 110) of the students explained that they had good clinical experiences because of supportive residents who were willing to help. MS K stated "I had residents who were willing to teach and guide my thinking." MS L wrote "residents were extremely helpful in directing us to information we would need to know to benefit our patients."

Table 4. Descriptive statistics and Mann-Whitney U test on clinical experiences in terms of professional development and access to attending physicians.

					Clinical Experiences					
	Overall Descriptive Statistics				Desirable		Undesirable			
	Score	n	%	Median (IQR)	n	Median (IQR)	n	Median (IQR)	*z*	*p* value
Clinical Proficiency (N = 137)				**3.0 (3.0 - 4.0)**	**108**	**3.0 (3.0 - 4.0)**	**27**	**2.0 (2.0 - 4.0)**	**-3.77**	**0.0001**
Having more than one medical learners working with the same educator...										
greatly interfered with my learning or clinical proficiency	1	3	2.2							
interfered with my learning or clinical proficiency	2	27	20							
did not have any effect	3	47	34							
improved my learning or clinical proficiency	4	53	39							
greatly improved my learning or clinical proficiency	5	7	5.1							
Professional Development (N = 137)				**3.0 (3.0 - 4.0)**	**108**	**3.0 (3.0 - 4.0)**	**27**	**3.0 (2.0 - 3.0)**		**0.0001**
Having more than one medical learners working with the same educator...										
greatly interfered with my professional development	1	2	1.5							
interfered with my professional development	2	17	12.4							
did not have any effect	3	63	46.0							
improved my professional development	4	45	32.8							
greatly improved my professional development	5	10	7.3							
Access to the Educator (N = 137)				**2.0 (1.0 - 2.0)**	**108**	**2.0 (2.0 - 2.0)**	**27**	**1.0 (1.0 - 2.0)**		**0.0001**
The number of medical learners working with an educator...										
negatively affected my access to the educator	1	37	27.0							
did not affect my access to the educator	2	79	57.7							
positively affected my access to the educator	3	21	15.3							

IQR = Interquartile range

Medical students who had undesirable clinical experiences. Twenty percent (27 of 137) of the respondents reported undesirable experiences with their clinical rotations. Three interconnected themes emerged from their data analyses as reasons for having undesirable clinical rotations: not enough patient exposure, group size/composition, and not enough one-on-one with attending.

Not enough patients to see. Thirty-seven percent (10 of 27) of the students attributed their undesirable clinical experiences to not having enough patient exposure for meaningful experiences. MS M who stated "There were not many patients to see during the rotations."

Group size and composition. Thirty-seven percent (10 of 27) of the students indicated that their undesirable clinical experiences were due to the group size of clinical learners working with a preceptor in busy clinical practices. MS N stated "I didn't get the most out of my summer rotation as there were about 4 learners working with a preceptor in a fast-paced environment." Likewise, other students did not like working in groups because of group dynamics. MS O wrote "grouping us together creates cues for group conformity that puts the impetus on not speaking. [It] was more difficult to ask questions." A similar observation was shared by MS P who indicated "too many learners reinforces the traditional hierarchical way of learning that is less effective and efficient than personalized, mutual respect learning."

Not enough time with attending. Twenty-six percent (7 of 27) of the students attributed their undesirable clinical experiences to not having enough time with the attending physicians. MS Q explained "not enough time with the attending and senior residents during the first four weeks." MS R's statement typified how the preceptors' workloads affected students' clinical experiences: "Residents and attending were too busy to teach."

DISCUSSION

This study provided information regarding medical students' experiences during clinical years of medical education at our institution. The findings demonstrated that most students have positive experiences during clinical years. Our data suggested that to provide optimal and quality learning experiences to medical students, they should be placed in supportive learning environments where they can participate in patient care confidently under the supervision of engaging preceptors and helpful residents.

The major findings demonstrated the impact of group size on students' clinical experiences, clinical proficiency, professional development, and access to attending physician. In particular, group size was a significant predictor for students' satisfaction during clinical experiences. Unlike the study by Rezmer and colleagues[7] who demonstrated no effect of group size on medical students' experiences during a resuscitation simulation learning module, our findings in clinical environments have shown there are differences among students' experiences working in groups ranging from two, three, or four in clinical settings.

Working in groups with other clinical learners provides camaraderie as learners can rely on each other for ideas and support, but group size and composition can affect students' learning experiences negatively. An advantage of working in smaller groups included students having more patient contact time, more contact time with attending and senior residents, and confidence in asking questions. Students in larger groups were less likely to ask questions and/or share an opinion on cases, especially in fast-paced clinical environments where medical teams have little time to care for many patients. One could argue that a group composed of learners at various levels of medical education would enhance knowledge, as clinical learners are able to learn from each other. However, larger groups often result in the traditional hierarchical way of learning where clinical attention is based on seniority. Thus, working with others in large groups could interfere with students' learning as well as negatively affect their access to the attending. Further research is indicated into why group size influenced medical students' perception of clinical proficiency development and access to the attending physicians, but did not have any effect on professional development.

The study had several limitations including a small sample size limiting generalizability of the findings, but it provided data on how group size affects medical students' experiences during clinical rotations. The study also was limited in its diversity. It was conducted at a single, urban medical educational institution and majority of its participants were Caucasian. Future studies should include larger and more diverse samples of students from other medical schools. Self-reported clinical experiences and possible recall bias also limit the findings of the study. Additionally, the study was limited by the fact that it measured medical student perception and not the impact on clinical opportunities during rotations.

In conclusion, our study has drawn attention to the evaluation of students' clinical experiences in medical education. To our knowledge, this is the first assessment that has looked into the effect of group size on medical students' experience in clinical settings. Varying group size appears to have an effect on medical students' clinical experiences. Medical students are more likely to have desirable clinical experiences when they are in smaller groups.

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Keywords: undergraduate medical education, clinical clerkships, group structure, professional autonomy

APPENDIX A

Medical Students' Perception of Experiences Survey

This questionnaire is part of a study to find out about your experiences working with other medical learners (residents, medical students, osteopathic (DO) student, physician assistant students, and nurse practitioner students) during your previous clinical rotations. The survey will take approximately five minutes to complete. Your participation is voluntary, and your responses will remain confidential. Your decision to participate will not in any way affect your standing at KUSM - Wichita now or in the future. We greatly appreciate your feedback. If you have any questions, please contact Dr. Samuel Ofei-Dodoo at sofeidodoo@kumc.edu or Dr. Kyle Goerl at Kyle.Goerl@via-christi.org.

1. Having more than one medical learner working with the same educator/supervisor...
    1. Greatly interfered with my learning or clinical proficiency
    2. Interfered with my learning or clinical proficiency
    3. Did not have any effect
    4. Improved my learning or clinical proficiency
    5. Greatly improved my learning or clinical proficiency

2. Having more than one medical learner working with the same educator/supervisor...
    1. Greatly interfered with my professional development
    2. Interfered with my professional development
    3. Did not have any effect
    4. Improved my professional development
    5. Greatly improved my professional development

3. The number of medical learners working with an educator/supervisor...
    1. Negatively affected my access to the educator/supervisor
    2. Did not affect my access to the educator/supervisor
    3. Positively affected my access to the educator/supervisor

4. During your previous clinical rotation, on average, how many learners (yourself included) worked with the same educator/supervisor at one time?
    1. 2
    2. 3
    3. 4
    4. Other (Please specify) _____

5. Did you get the most out of your clinical experiences during your previous rotation? ___Yes ___No
    a. Why and why not? _____
    _____
    _____
    _____
    _____

6. In your opinion, what should be done to improve clinical rotations so you could get the most out of the experience? _____
_____
_____
_____
_____

Please tell us about yourself:

7. Year of birth _____

8. Gender: _____Male _____Female

9. Race or cultural group do you identify with? (please circle one)
    1 = African American
    2 = Caucasian
    3 = Hispanic/Latino
    4 = Asian
    5 = Bi-racial
    6 = Other

10. I am a...
    1 = third year medical student
    2 = fourth year medical student

CASE REPORT

Is it a Drug or a Bug? A Case of Chemotherapy and Immune Modulators Complicating the Diagnosis of Ehrlichiosis

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INTRODUCTION

Ehrlichiosis is caused primarily by *Ehrlichia chaffeensis* and *Ehrlichia ewingii*.[1,2] These obligate intracellular gram-negative coccobacilli are transmitted by arthropod vectors. They reside in vertebrate reservoirs and undergo a tick-mammal-tick cycle during which humans are dead-end hosts. The life cycle of *E. chaffeensis* is perpetuated predominantly via the *A. americanum* (Lone star) tick.[1,2] During human infection, *E. chaffeensis* preferentially targets monocytes. Men are affected more often than women. Individuals between the ages of 65 and 69 had the highest incidence rate (IR) between 2008 and 2012.[1,3] During this period, Oklahoma and Missouri had the highest IR at 30.9 and 26.3 per million, respectively.[3] Patients with hematologic malignancies undergoing chemotherapy can have similar symptoms to those found in ehrlichiosis without being infected. However, in the appropriate setting, tick-borne illness should be considered. We present a case of severe illness and prolonged fevers due to ehrlichiosis in a patient who received chemotherapy for chronic lymphocytic leukemia (CLL).

CASE REPORT

A 77-year-old man with CLL who completed six cycles of bendamustine and rituximab three months prior, presented in early August with complaints of fevers, night sweats, decreased appetite, and nausea for one month and was found to have a white blood count (WBC) of 1.5K/μL. This patient had asymptomatic persistent leukopenia following therapy into mid-May and mid-July. The patient was seen in the emergency department and in clinic by his oncologist, where he was febrile up to 39.3ºC, and subjectively had fatigue, myalgias, and arthralgias. The work-up, including chest x-ray, blood cultures, and urinalysis, was negative. He was treated empirically with levofloxacin and amoxicillin-clavulanic acid. In addition, he received seven doses of filgrastim (human-granulocyte colony stimulating factor) during his course of antibiotics.

After completion of antibiotics, the patient had a brief period of a few days where he felt well enough to proceed with vacation plans. During his vacation, his symptoms recurred and worsened quickly. He presented to clinic immediately after his vacation and noted darkening of his urine secondary to presumed dehydration, in addition to his previous symptoms. At that time, his labs were significant for hyponatremia, elevated glucose, lactate dehydrogenase of 275 μ/L, AST of 56 μ/L, ALT of 56 μ/L, alkaline phosphatase of 91 μ/L, a normal WBC, and a platelet count of 271 x 106 /μL. Attempts were made to manage at home, but with ongoing worsening of his condition after three days, he was instructed by his oncologist to be admitted to the hospital.

New symptoms on admission included altered mental status and insomnia. On admission, he was febrile and physical exam was pertinent for rales in bilateral lung bases, and he was without rash, focal neurological deficits, or lymphadenopathy. CT of his sinuses, chest, abdomen, and pelvis demonstrated no abnormal lymphadenopathy or nidus of infection. His labs were notable for normal white blood count of 5.2 K/μL, with a platelet count of 49,000 K/μL. Ferritin was > 7500 ng/mL and his AST and ALT were 141 μ/L and 81 μ/L, respectively.

Based on his ferritin level, there was concern for hemophagocytic lymphohistiocytosis. A bone marrow biopsy demonstrated residual CLL without evidence of hemophagocytosis or macrophage predominance. On the second day of admission, infectious disease was consulted. They empirically started amphotericin, imipenem, and doxycycline. Over the next 24 hours, the patient worsened with persistent fever, rigors, altered mental status, tachypnea, and a new oxygen requirement. Repeat chest imaging revealed pulmonary edema.

The patient was transferred to the intensive care unit for acute hypoxic respiratory failure. Infectious disease labs that were obtained on consultation at admission were positive for *Ehrlichia chaffeensis* by polymerase chain reaction. His antibiotics were narrowed to doxycycline, the patient clinically improved over the course of two weeks, and his labs normalized after a 10-day course of doxycycline.

DISCUSSION

Human ehrlichiosis is a clinical syndrome characterized by fever and cytopenias. The median incubation period is eight days. Only 57% of confirmed cases are associated with a known tick bite.[4] Fever is a prominent symptom (96%) along with malaise (77%), headache (72%), and myalgias (68%). Rash is seen uncommonly at presentation (6%), but approximately 26% of patients will develop a rash. Other symptoms include gastrointestinal symptoms (25 - 57%), cough (28%), and confusion (20%). The mortality rate is approximately 2%. Laboratory values can demonstrate an elevation in ALT and AST (84% of patients), leukopenia (61%), and thrombocytopenia (73%). Laboratory findings can include a mild-moderate elevation in alkaline phosphatase and LDH.[1,2,5] Diagnosis is commonly achieved using PCR which is most sensitive during early infection. Paired indirect fluorescence antibody (IFA) assays are considered the gold-standard for serologic diagnosis, but take weeks to perform.[6]

Our patient's course was longer than most and he had a period of brief improvement. He experienced approximately 20 days of relapsing fevers and worsening symptoms prior to hospitalization. A case series of ehrlichiosis as a cause of a prolonged fever found fevers ranged between 17 - 51 days.[7] The patients in this series had various clinical manifestations, but defervescence occurred shortly after doxycycline therapy. One of these patients had the illness resolve after 30 days of a relapsing fever.

Case reports on whether ehrlichiosis is more severe in immunocompromised individuals are conflicting.[8,9] A retrospective study by Thomas et al.[8] found no significant difference in ICU admissions, duration of hospital stay, presenting lab values, or severity of illness between immune competent and immunosuppressed patients. Conversely, Safdar et al.[9] found a 25% mortality rate for immune compromised individuals. In addition, they found that almost all 23 cases reviewed demonstrated significant organ dysfunction. Finally, a 2016 analysis of national surveillance data for *Ehrlichia chaffeensis* infections showed an increased risk of hospitalization, life-threatening complications, and death among immune compromised individuals.[3] This patient developed pulmonary edema and pleural effusions. Several case series found that pleural effusions or pulmonary involvement may be more common in the immunocompromised population manifesting as abnormal pulse oximetry, or abnormal pulmonary examination.[4,5,10-12] A delay in diagnosis and by extension a delay in the administration of doxycycline, may explain the difference in severity. Delayed doxycycline therapy is associated with increased rates of ICU transfers, rates of mechanical ventilation, longer hospital stays, and overall length of illness.[13]

Lastly, filgrastim is associated with relatively common adverse effects of bone pain, fatigue, headache, and fever.[14] His frequent injections with filgrastim early in the clinical course may have complicated the initial presentation by boosting his WBC count and, to some extent, his platelets and the non-specific adverse effects.

CONCLUSION

Our patient's diagnosis was nebulous secondary to a recent history of cytotoxic chemotherapy and immune modulating drugs. The similarity of the adverse effects of these medications with our patient's clinical presentation of ehrlichiosis proved a diagnostic dilemma. The acute drop in an already low platelet count was an early suggestion of ehrlichiosis. In general, any patient presenting in the summer months with headache, fever, cytopenias, and/or elevated AST/ALT should be considered for empiric doxycycline therapy and diagnostic testing. In our review, we concluded that individuals with a compromised immune system develop more severe disease with *Ehrlichiosis spp*. It is unknown whether this is a product of individual susceptibility or delays in diagnosis. It is important to consider tick borne illnesses, including ehrlichiosis, in an immunocompromised patient presenting with fevers and cytopenias, especially if the patient has a recent history of a tick bite and lives in endemic area.

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Keywords: ehrlichiosis, immunocompromised patient, leukemia, chemotherapy, tick-borne diseases

CASE REPORT

Evaluation of Syncope Reveals Cardiac Amyloidosis

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INTRODUCTION

Tissue deposition of protein fibrils causes a group of rare diseases called systemic amyloidosis.[1] The most frequent type in high-income countries is AL amyloidosis, which is an acquired systemic immunoglobulin light chain amyloidosis. There is a paucity of epidemiological data for this systemic disease. The first population-based study of AL amyloidosis in the United States came out of Olmsted County, MN, and was published in 1992.[2] It reported the incidence of AL amyloidosis as three to five cases per million population.

This case report and literature review is intended to increase clinicians' awareness about this disease because early diagnosis of AL amyloidosis will have significant impact on a patient's morbidity and mortality. We describe a patient who presented with the primary concern of syncope secondary to cardiac amyloidosis (AL-type).

CASE REPORT

An 81-year-old male with a past medical history of congestive heart failure with preserved ejection fraction, paroxysmal atrial fibrillation, monoclonal gammopathy of undetermined significance (MGUS), carpel tunnel syndrome, peripheral neuropathy, and chronic transudative pleural effusions was referred to the hospital by his primary care physician with a chief complaint of syncope, which had been getting progressively worse over the prior two months. He also complained of weakness, fatigue, chronic diarrhea, numbness, tingling, easy bruising, and easy bleeding. The patient listed only two medications that he was taking, warfarin and vitamin D supplementation.

On admission, he was afebrile. His blood pressure was 160/80 mmHg, heart rate 91 beats per minute, respirations of 22 breaths per minute, and he was 99% SpO2 on room air. Orthostatic vitals were taken: sitting blood pressure 147/86 mmHg and pulse 89 bpm; standing blood pressure was 118/66 mmHg and pulse 100 bpm. He was awake, alert, and oriented. No scleral icterus was present. He had jugular venous distention. Grade II/VI systolic ejection murmur was noted at the right upper sternal border and 2nd intercostal space without radiation to the carotids. Diffuse crackles were present but no wheezes. There was no labored breathing.

On abdominal examination, there was no tenderness to palpation, normoactive bowel sounds were present, and no masses or hepatosplenomegaly were palpated. Rectal exam revealed a weak rectal tone without masses, fissures, or hemorrhoids. There was 1+ pitting edema to the mid-anterior shin bilaterally without cyanosis or clubbing. There were multiple purpuric, non-pruritic, non-blanching purplish lesions noted on the right neck and lower extremities. Neurological examination revealed no gross cranial nerve abnormalities, strength testing of 5/5 throughout, and normal sensation.

Pertinent lab data revealed normocytic anemia, INR 2.2, creatinine 1.52 mg/dL (no known baseline), urea 32 mg/dL, normal liver function tests, and normal electrolytes. Urine studies showed 2+ protein, 1+ blood, negative nitrite, negative leukocyte esterase, and 2-5 hyaline casts. Brain natriuretic peptide was 1478 pg/mL and troponin mildly elevated at 0.08 ng/mL. TSH, aldolase, cortisol level, erythrocyte sedimentation rate, rheumatoid factor, anti-cyclic citrullinated peptide were within normal limits. Vitamin B12 was low at 276 pg/mL. He had an ANA elevated at 1:640 titer with a speckled pattern.

Chest x-ray revealed an enlarged cardiac silhouette, reticular linear opacities noted bilaterally, but no pneumothorax or alveolar consolidation. CT of the chest revealed reticular sub-pleural fibrosis, no significant honeycombing, and bilateral pleural effusions. Electrocardiogram (ECG) revealed a sinus rhythm, rate in the 90s, and left bundle branch block (baseline unknown); normal voltage criteria were met. A 2-D+Doppler echocardiogram revealed a left ventricular ejection fraction of 45%, Grade III (severe) diastolic dysfunction, moderate concentric bi-ventricular hypertrophy, dilated left and right atria, and no pericardial effusion. He had an echocardiogram four months prior to his admission demonstrating a left ventricular ejection fraction of 60%, moderate concentric left ventricular hypertrophy, and Grade II (moderate) left ventricular diastolic dysfunction). Of note, the patient did not have valvular abnormalities noted on the echocardiogram but auscultation revealed a Grade II/VI systolic ejection murmur. One of the most common ascultatory findings is a systolic murmur and, among elderly patients, the prevalence of systolic murmurs ranges from 29% to 60%, and results of echocardiography are normal in 44% to 100% of cases.[3] Cardiology was consulted because of concern for cardiac amyloidosis.

Cardiac catheterization revealed that the patient was unlikely to have a restrictive cardiomyopathy, as the diastolic pressures in both the right and left ventricle were below normal. Fat pad biopsy did not reveal amyloidosis. He followed up with outpatient cardiology and underwent implantation of a permanent pacemaker for symptomatic tachycardia-bradycardia syndrome. He also underwent an endomyocardial biopsy that revealed "early stages" of AL amyloidosis. A bone marrow biopsy revealed 8% monoclonal lambda plasma cells, and free light chains showed markedly increased lambda light chains and mildly elevated kappa light chains. Serum protein electrophoresis showed a monoclonal spike in beta/gamma regions.

Urine immunofixation revealed IgG lambda. The patient was referred to outpatient oncology where he was started on melphalan and dexamethasone for AL amyloidosis.

DISCUSSION

Our patient had AL amyloidosis, which is a plasma cell dyscrasia that is related to multiple myeloma[4] and MGUS.[5] The major organs commonly involved in AL amyloidosis are the kidney, heart, nervous system, skin, and gastrointestinal system. Our patient likely developed chronic kidney disease secondary to his underlying amyloidosis. Proteinuria, cardiomyopathy, abnormal cardiac conduction, autonomic neuropathy, chronic diarrhea, and capillary fragility due to amyloid infiltration were present in our patient. The severity and number of organs involved determine the prognosis of AL amyloidosis. In fact, cardiac involvement carries the worst prognosis, with a median survival in the untreated patient of about six months from the onset of congestive heart failure.[6] Death in cardiac AL amyloidosis occurs either as a result of progressive heart failure or sudden cardiac death.[7]

The role of a prophylactic implantable cardioverter-defibrillator (ICD) remains indefinable in preventing sudden cardiac death as pulseless electrical activity is the most common cause of death which is a non-shockable rhythm. Electrocardiogram findings in amyloidosis may lead incorrectly to suspicion of coronary artery disease.[8] On echocardiogram, wall thickening in amyloidosis is due to infiltration and, unlike true left ventricular hypertrophy in which ECG voltage is increased, the voltage in amyloidosis is low, providing a strong clue to the presence of an infiltrative myocardial disorder.[9] Understanding what to expect on ECG or echocardiogram in a patient presenting with a constellation of symptoms is important in diagnosing AL amyloidosis.

CONCLUSION

Prompt recognition of cardiac amyloidosis is important in evaluation of patients with syncope because of its poor prognosis if left untreated. Despite diagnostic modalities such as echocardiogram, computed tomography, and cytogenetic testing, history and physical examination remain the most valuable tools in a physician's armamentarium. In conclusion, AL amyloidosis must be suspected in patients presenting with syncope in the setting of autonomic neuropathy, proteinuria, cardiomyopathy, chronic diarrhea, and purpura.

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Keywords: amyloidosis, hereditary, transthyretin-related, syncope, plasma cell dyscrasia

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Optimal Management of a Pregnant Patient with Rheumatic Heart Disease

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INTRODUCTION

Rheumatic heart disease remains the number one worldwide cause of maternal cardiac complications in pregnancy.[1] Since symptoms of rheumatic fever typically do not present until the fourth or fifth decade, the pathophysiologic changes associated with pregnancy may cause as many as 25% of these women to first experience symptoms during pregnancy. For this reason, it is important that obstetric anesthesiologists remain aware of the disease, its complications, and management of valvular lesions throughout the birthing process.

The normal physiologic changes of pregnancy cause unique problems to the mother with underlying cardiac disease.[2] Intravascular volume and cardiac output (CO) increase while systemic vascular resistance (SVR) decreases to preserve normal mean arterial pressure (MAP). During labor, each uterine contraction results in an auto transfusion of blood, resulting in even higher CO.[3] Likewise, pain and apprehension can lead to sympathetically mediated increases in SVR, heart rate (HR), and CO causing further stress.[2] Yet, the greatest stress comes immediately after delivery when uterine contraction and involution can increase CO by as much as 80% above third trimester values.[3]

With all these changes, one must realize how valvular disease is affected during pregnancy. In general, regurgitant lesions are tolerated better due to the increase in intravascular volume and the decrease in SVR, thus improving forward flow of blood through the valves.[2,3] In contrast, stenotic lesions are tolerated poorly due to the inability to increase CO through a stenotic valve in the setting of increased intravascular volume and increased preload.[2]

In patients with rheumatic heart disease, mitral stenosis is the most common heart lesion.[1] When these patients become pregnant, the hypervolemia and increased HR can increase the transmitral pressure gradient, leading to increased left atrial volume and pressure. Pressure can be transmitted to the pulmonary vasculature, resulting in pulmonary edema and in severe cases pulmonary hypertension, a significant risk during pregnancy as it can cause right heart failure.[4] Further, the chronically dilated left atrium has a propensity to disrupt the cardiac conducting system and cause supraventricular tachycardia,[1] a detrimental event in patients with mitral stenosis who rely on the atrial kick to augment preload. Overall, these factors often cause the previously undiagnosed and asymptomatic patient to develop symptoms during pregnancy, and, in severe cases, experience profound cardiac decompensation.

CASE REPORT

A 30-year-old Hispanic female, Gravida 11, Para 3-1-6-4, at 33 weeks pregnant presented with a complaint of "increasing pressure in her abdomen". The patient was not in labor, but her history included a "leaky heart valve" which was described as rheumatic fever. She previously had been told not to have further pregnancies. She had no history of anesthesia or epidural, and no medication other than a prenatal vitamin. The patient lived in a small town about one hour outside of the city. Her chart noted poor medical compliance. She denied chest pain, shortness of breath, presyncope, or palpitations. On exam, a diastolic murmur was appreciated, most notably at the apex. There was no jugular venous distension or edema, and her lungs were clear on auscultation.

An echocardiogram showed moderate mitral stenosis with severe mitral regurgitation, severe pulmonary hypertension, moderate aortic insufficiency with no evidence of stenosis, and chronic diastolic heart failure with an ejection fraction of 60%, clinically well compensated at the time. The patient returned home with plans for close surveillance and for postpartum transesophageal echocardiography.

Two weeks later the patient returned at 35 weeks pregnant with the same abdominal pressure complaints and again was found not to be in labor. As she had missed a follow-up appointment, she was admitted and watched as an inpatient until delivery due to noncompliance with her checkups and to avoid delivery with her heart disease at a small hospital an hour away. She was placed on venous thromboembolism prophylaxis with subcutaneous heparin 10,000 units BID. The cardiology and obstetric teams rounded on her daily. Early in her stay, the patient complained of palpitations and was placed on continuous telemetry, which showed occasional premature atrial and ventricular contractions. These improved without medication.

Nine days after admission, a multidisciplinary joint meeting was held between obstetrics, cardiology, and anesthesia to discuss a plan for delivery. Cardiology noted that the patient appeared well compensated and optimized for delivery. The most worrisome heart lesion was the stenotic mitral valve, and the best management was to keep the patient euvolemic, preferring slight hypovolemia to hypervolemia. She would be scheduled for induction of labor a couple weeks later in her 39th week of pregnancy. The team agreed an epidural block would be placed and titrated slowly for pain management. She would be encouraged to avoid Valsalva maneuvers during delivery with plans for forceps-assisted vaginal delivery to shorten the second stage of labor. Tentatively, a bilateral tubal ligation was scheduled for after delivery. Post-operatively, cardiology would begin loop diuretics to ensure diuresis and minimize the risk of hypervolemic complications after uterine involution.

On the day of induction at 08:44, an epidural catheter was placed in the usual manner with an initial negative test dose. The epidural was set with a rate of 10 mL/hr of 0.125% bupivacaine with 2 µg/ml fentanyl. The patient experienced minimal drop in blood pressure

after epidural placement to a nadir of 95/50 mmHg, while HR remained about 90 beats per minute (bpm). As she remained stable, bupivacaine was bolused manually in increasing doses throughout the morning and the sensory level block gradually crept to T7 bilaterally by 11:00 and T6 bilaterally by 12:30 when the cervix reached full dilation. Toward the end of delivery, the patient began to experience chest pain. Her vital signs remained relatively unchanged throughout.

Stage two of labor was expedited with forceps as planned, and a healthy baby girl was delivered at 12:56. The placenta was delivered four minutes later. A 12-lead electrocardiogram obtained at this time, showed normal sinus rhythm at 91 bpm with bi-atrial enlargement and left ventricular hypertrophy, essentially unchanged from admission. The patient received oxytocin and misoprostol, and blood loss was noted to be 350 mL. After delivery, the patient's chest pain gradually resided. The epidural catheter was left in place with basal rate continued for possible tubal ligation surgery later that day.

As the chest pain had resolved and the patient felt better, postpartum tubal ligation was initiated. When the patient arrived in the operating room at 14:25, her BP was 110/40 mmHg with HR of 90 bpm. When the obstetrician arrived, the patient had continued to bleed postpartum, losing approximately 740 mL more blood. She had not been resuscitated due to the obstetrician's concern of the complications of hypervolemia, namely heart failure. Therefore, she was resuscitated with lactated ringers (LR) and given two 100 µg doses of phenylephrine. The patient responded well, BP increased appropriately, and the epidural catheter was bolused at 14:45 with 10 mL of 2% lidocaine over 15 minutes. Surgery started at 14:55. The patient required a 20 mg and a 30 mg dose of esmolol when HR exceeded 100 beats per minute, but otherwise tolerated the procedure well. A total of 900 mL of LR was given throughout. The patient remained stable in the recovery unit and the epidural catheter was removed. The anesthesiologist called the cardiologist to give a report, and diuretics were started that night as planned. The patient diuresed well, her chest pain never returned, and on postpartum day three cardiology declared her stable for discharge and she left the hospital. After discharge, the patient was referred to a cardiac surgeon for possible mitral valve surgery.

DISCUSSION

This case showed the importance of communication between the multiple specialties required to care for complex patients. The multidisciplinary meeting before delivery allowed concerns to be addressed and a plan to be made, as well as prepare to manage complications. When communication breaks down, for instance being unaware of the further blood loss causing hypotension, critical factors affecting treatment may be left out. But when effective communication takes place, such as timely hand off with the cardiologist after surgery, the patient can be started more efficiently on diuretics to optimize her fluid status. Clearly, with good communication, patient care is improved.

In general, when caring for parturients with valvular lesions, a cesarean delivery should be reserved for obstetric indications only,[1,2] as it is associated with more blood loss, increased risk of wound infection, post-operative immobility, and thrombosis.[1] Euvolemia should be maintained with strict monitoring of intake and output. Lumbar epidural anesthesia is preferred to control pain and limit hemodynamic changes due to sympathetic tone, and to limit the urge to push.[1] Local anesthetics should be titrated slowly, as a sudden decrease in preload or SVR may be tolerated poorly when the patient develops reflex tachycardia.[2] As in our patient, the addition of opioids to the local anesthetic mixture may improve pain control without adding to sympathetic blockade, thus worsening SVR. Likewise, an adequate block can decrease patient Valsalva maneuvers, which cause the undesirable effect of increased SVR and may cause circulatory overload. Assisting delivery with forceps or vacuum extraction also minimizes the need for Valsalva maneuvers.[1]

Due to the fact that arrhythmia could cause significant decompensation, continuous telemetry is required.[1] Anticoagulation is utilized to prevent systemic embolism. Along with the added hypercoagulability of pregnancy, patients with a dilated left atrium and a lesion such as mitral stenosis, where supraventricular tachycardia is not uncommon, are at significant risk of left atrial thrombus formation and stroke. In our patient, unfractionated heparin usually is utilized after 36 weeks gestation, or two to three weeks before expected delivery, due to its shorter half-life and the ability to rapidly reverse. Heparin can be safely discontinued four to six hours before delivery. Similarly, this is another reason to prefer vaginal delivery, as improved mobility postpartum decreases thromboembolism risk.

With regards to mitral stenosis, perhaps the most important point is to maintain sinus rhythm if present pre-operatively and to prevent tachycardia.[3] Time required for adequate left ventricular diastolic filling is prolonged, thus it is more reliant on sufficient diastolic time along with atrial kick.[2] For the most part, our patient maintained normal heart rate with adequate pain control throughout, and esmolol was utilized when appropriate to control tachycardia. Ephedrine should be avoided as it may result in tachycardia. The pressor of choice is phenylephrine, as it has little effect on uteroplacental perfusion and the reflex decrease in HR it is known to cause can be beneficial in patients with mitral stenosis.

In our patient, who was well compensated and asymptomatic before labor, increased vigilance, but not necessarily invasive monitoring, was required.[2] If she had been symptomatic prior to labor, the stress of delivery and increase in postpartum blood volume could have put her at serious risk of cardiovascular collapse, and an arterial line may have been necessary. Serial echocardiography also may be beneficial in this setting. As mentioned, one of the most stressful moments on the cardiovascular system is immediately after delivery when uterine involution greatly increases blood volume and cardiac output. Similarly, as the sympathetic block wears off, the intravascular load may worsen and be tolerated poorly by patients with stenotic lesions and fixed cardiac output. In our patient, diuresis shortly after surgery was important, as many maternal complications can happen in the week after delivery, or even months later.[5]

One thing to consider in this case was whether the timing of tubal ligation was appropriate. In patients with mitral stenosis, a moment of great strain on the heart shortly after delivery may increase intravascular volume and overload the cardiovascular system leading to pulmonary edema. Our patient already was known to have pulmonary hypertension. In addition, even though the electrocardiogram was unchanged, our patient developed chest pain during delivery. On the other hand, she had a history of poor medical compliance, and if she were to become pregnant again, a delivery would be even riskier. After discussing contraceptive options with the obstetric team, the patient decided on permanent sterility. As the epidural catheter was in place and the patient did not appear volume overloaded, it was determined she could undergo surgery safely. When the patient was hypotensive, it was appropriate to delay until after fluid resuscitation had improved her blood pressure and shown her to be fluid responsive. This stabilized her prior to another epidural bolus and provided further evidence that her hypotension was not due to volume overload and heart failure.

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Keywords: rheumatic heart disease, obstetric anesthesia, mitral stenosis, case report

CASE REPORT

Focal Myopericarditis Presenting as Acute ST-Elevation Myocardial Infarction

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INTRODUCTION

Myopericarditis is an inflammation of the myocardial and the pericardial layers of the heart.[1] Acute myopericarditis commonly is caused by viral illness, however less commonly, it may be caused by non-infectious etiologies. Myocarditis, which is an inflammation of the myocardium, can be divided into acute, sub-acute, or chronic. Based on the histology, these can be classified as active or borderline myocarditis by the Dallas criteria for interpretation of endomyocardial biopsy. The disease may either affect a focal part of the myocardium or have diffuse involvement.

The incidence of myocarditis and pericarditis is 22 - 27.7/100,000 and the incidence of myopericarditis is even less.[2] Myocarditis is reported to be the reason for 0.5% to 3.5% of the heart failure hospitalizations all over the world.[3] While myocarditis is a well-known presentation, focal myopericarditis is rare. Focal myopericarditis can mimic an acute ST-elevation myocardial infarction, which often requires prompt treatment with invasive angiography. This identical presentation makes diagnosis of focal myopericarditis difficult, and thus, clinical suspicion is essential for diagnosis. With growing population presenting as MI from coronary plaque ruptures, the diagnosis of focal myopericarditis remains challenging. Its clinical presentation may vary from subtle to life-threatening to even death.

We present a Caucasian female with chest pain and ST-elevation on electrocardiogram (ECG) who was found to have focal myopericarditis.

CASE REPORT

An 18-year-old previously healthy female presented to the emergency room for crushing chest pain. She woke up at 0800 with mid-sternal chest pain radiating to her back and bilateral arms with associated symptoms of shortness of air at rest. She denied cough, rhinorrhea, nasal congestion, nausea, vomiting, diarrhea, or diaphoresis. She reported no change in quality of pain with position or inspiration. She did not have any past surgical history or history of premature coronary artery disease in her family. The patient smoked 1 - 2 cigarettes per day, but denied illicit drug or alcohol abuse.

Physical examination in the emergency room was notable for regular heart rhythm without murmurs, gallops, or rubs. She was afebrile with a heart rate of 74 bpm, respiratory rate of 12, blood pressure of 137/93 mmHg, and oxygen saturation was 99% on room air. She had no peripheral edema or jugular venous distention. Her lungs were clear to auscultation. An electrocardiogram (ECG) on presentation showed ST-elevation in the inferior wall distribution (Leads II, III, and aVF) with non-specific PR interval changes (Figure 1). Troponin I was 0.06 ng/mL on admission (reference normal <0.07ng/mL), which peaked to 22.88 ng/mL at 12 hours after admission. CT-angiography of the chest ruled out aortic dissection and pulmonary embolism. Echocardiogram at bedside revealed inferior wall hypokinesis, which was concerning for a plaque rupture, thus, she was taken for cardiac catheterization while the troponin was trending up (from 0.06 to 1.06 ng/mL four hours after admission).

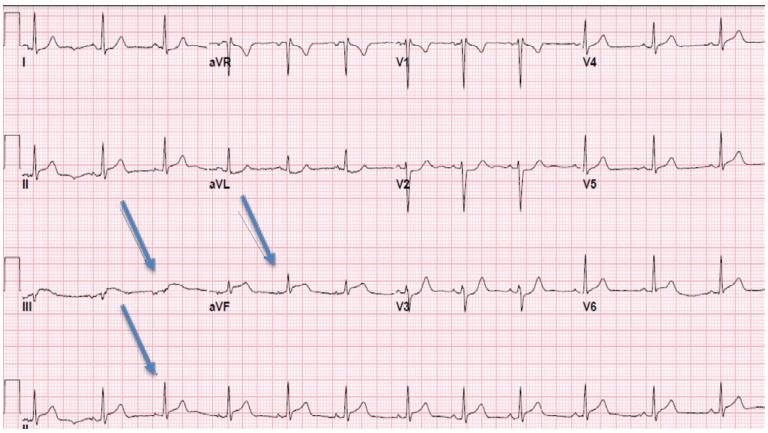

Figure 1. Admission ECG showing ST-segment elevation in inferior leads II, III, and aVF (arrows).

Cardiac catheterization revealed patent coronary arteries with hypokinesis of the inferior wall on left ventriculogram (Figure 2). Echocardiogram showed left ventricular ejection fraction of 55 - 60% with mild degree of hypokinesis in the inferior wall. Complete blood count, renal function panel, thyroid function studies, erythrocyte sedimentation rate, C-reactive protein, and urine drug screens were normal. Fasting lipid panel showed elevated total cholesterol at 213 mg/dL and low density lipoprotein (LDL) at 136 mg/dL with a normal high density lipoprotein (HDL) at 66 mg/dL. Because of a negative heart catheterization with ST segment elevation on ECG and troponin elevation, coronary vasospasm and myopericarditis were high among the differential diagnosis. Troponin I trended down after the 12-hour peak, and the patient was stable with chest pain resolved. She was discharged after 24 hours to have a close outpatient follow-up for a cardiac MRI (CMR). With the exception of nonsteroidal anti-inflammatories as needed, no new medications, including anticoagulants, were prescribed at the time of discharge.

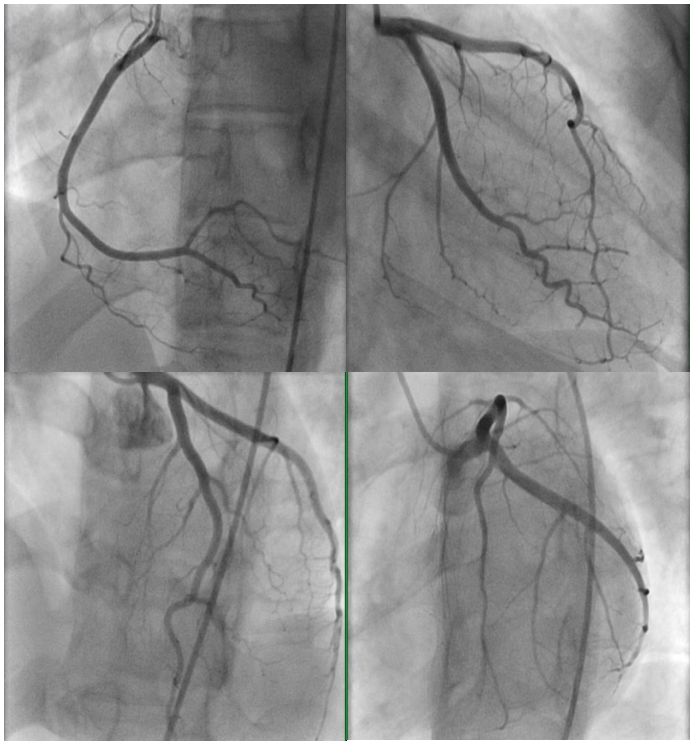

Figure 2. Angiography of the left heart vessels shows patent right (top left image) and left coronary (top right and lower images) arteries and branches.

At two-week follow-up, the patient was symptom-free with a normal ECG (Figure 3). To support the clinical diagnosis of myopericarditis and rule out other possible causes of non-ischemic cardiomyopathy, she underwent a cardiac magnetic resonance imaging (CMR) as an outpatient, which revealed hypokinesis of the lateral and inferior wall of the left ventricle apex with epicardial and transmural delayed enhancement, suggestive of focal myopericarditis (Figure 4).

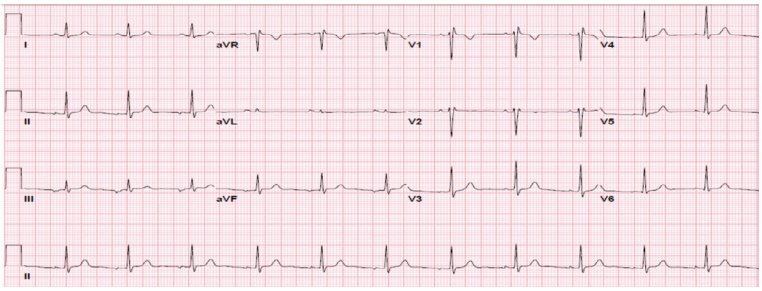

Figure 3. A 2-week follow-up ECG showing resolution of the ST-segment elevation.

DISCUSSION

Given the patient's age, drug abuse causing vasospasm, aortic dissection, and thromboembolic causes were high on the differential diagnoses, but these were ruled out by history, vital signs, and administration of sublingual nitroglycerin. Myocarditis and pericarditis were low on the differential as they typically present with diffuse ST segment changes on ECG. Clinical presentation is the key in this particular diagnosis; however in our patient, she denied having any prodromal viral or gastrointestinal illness which made it more difficult. Of note, our patient remained afebrile during the entirety of her hospitalization. Several factors can trigger coronary vasospasm, such as use of cocaine, amphetamine, marijuana, chemotherapy drugs, over-the-counter medications, and antibiotics. Our patient did not have exposure to any of these.

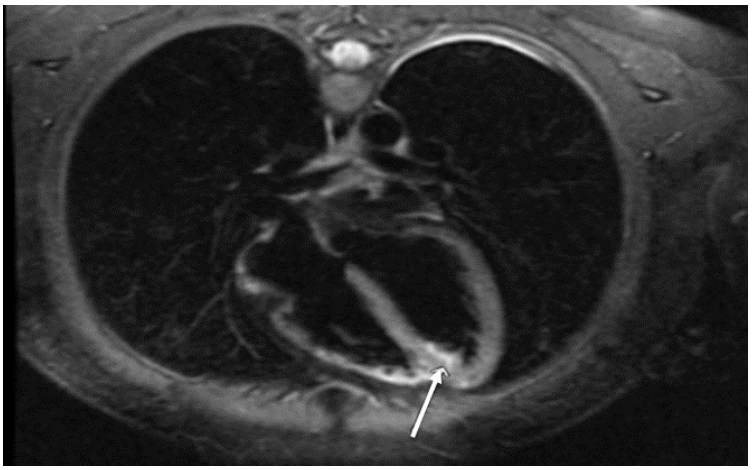

Figure 4. CMR showed epicardial and transmural delayed enhancement, suggestive of focal myopericarditis (arrow).

Coronary artery spasm is a multifactorial disease with underlying mechanism that is still poorly understood.[4] Typically, coronary artery spasm will reveal stenosis during cardiac catheterization during both systole and diastole and responds to calcium channel blockers and nitroglycerin. Myopericarditis typically follows history of fever. A history of upper respiratory infection symptoms often helps, but its absence does not rule out the disease. Ultimately, to differentiate the two, diagnostic tools such as enhanced imaging techniques like CMR and/or invasive coronary angiography come into play to make the correct diagnosis.

ST-elevation myocardial infarction is the most important differential diagnosis of focal myopericarditis among others.[5] Myopericarditis shows a characteristic pattern of contrast enhancement on CMR, which originates primarily from the epicardium, sparing the subendocardial layer. Myopericarditis need not always have elevated ESR and CRP as they are only positive in 60% of the cases.[6] Indications for endomyocardial biopsy (EMB) include new-onset heart failure of less than two weeks duration associated with hemodynamic compromise which is unexplained, new-onset heart failure of two weeks to three months duration associated with a dilated left ventricle, new ventricular arrhythmias with no certain explanation, Mobitz type II second-degree atrioventricular (AV) block, third-degree atrioventricular (AV) block, or refractory heart failure.[7] Biopsy is indicated in these instances to evaluate for possible rare diagnoses such as giant cell myocarditis (where early diagnosis prompts potential preparation for transplantation), lymphocytic myocarditis, sarcoidosis (response to restrictive cardiomyopathy from steroids which are not otherwise used for routine heart failure treatment), dilated cardiomyopathy due to eospinophilia (high-dose steroid responsive), amyloidosis, and hemochromatosis. These different etiologies have unconventional heart failure treatment and present acutely, thus EMB may help in this situation. Dallas Criteria (histologic criteria) have an overall low diagnostic yield according to one case series of 1,230 patients.[8]

Diagnosis of myopericarditis is empiric and made on clinical presentation. ECG changes, elevated cardiac enzymes, lack of epicardial coronary artery disease, and abnormal CMR support the diagnosis.[9] Myopericarditis shows a characteristic pattern of contrast enhancement on CMR, which originates from the epicardium, sparing the subendocardial layer.[10] Positron emission tomography (PET) also can be used to assess for occult inflammation.[11] Indications for endomyocardial biopsy exist, but the sensitivity and specificity of EMB are approximately 60% and 80%, respectively, and autopsy is the gold standard.[12] A lower sensitivity of 35% has been noted when a clinical and functional gold standard is used.[13] Treatment is supportive for myopericarditis and case-dependent. Clinicians must have a high clinical suspicion for the diagnosis of myopericarditis with elevated cardiac enzymes and ST elevation in absence of coronary artery disease.

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