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Reducing Hypotension and Acute Kidney Injury in the Elective Total Joint Arthroplasty Population: A Multi-Disciplinary Approach

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ABSTRACT

Background: When critically analyzing our hospital system's rate of hypotension and acute kidney injury (AKI) after total joint arthroplasty, our incidence rates (14.54%, 6.02%) were much higher than our peers (7.17%, 2.03%) and national rates (2.0%, 3.3%). We present a multi-disciplinary management intervention that aimed to decrease overall complication rates.

Method: A multi-disciplinary team implemented a protocol at our suburban hospital to limit complication rates after joint replacement surgery. Hypotension, AKI, length of stay (LOS), re-admission rates, and mortality rates were compared before the protocol was implemented, after protocol implementation, and after protocol integration into our EMR (electronic medical record).

Results: In total, 1233 patients over 36 months were followed. Hypotension rates after protocol implementation into EMR (group 3) were significantly lower than rates before the protocol (group 1) ($P = .002$), with rates after protocol implementation without EMR (group 2) trending toward a significant decrease from group 1 ($P = .064$). AKI rates in group 3 were significantly lower than group 1 ($P = .000$) and group 2 ($P = .006$). No difference was seen in hypotension rates between group 2 and 3 ($P = .792$) or AKI rates between group 1 and 2 ($P = .533$). Finally, no significant difference was seen between groups in LOS ($P = .560$), re-admission rates ($P = .378$), and mortality rates (all 0.0%).

Conclusion: By implementing a comprehensive electronic protocol consisting of pre-operative risk stratification, multi-disciplinary medical optimization, and an evolving post-operative management plan, significant decreases in hypotension and AKI can be seen.

As surgical capabilities have advanced overtime, total joint arthroplasty (TJA) has been regarded as a crucial orthopedic surgical intervention when treating damaged joints in hopes of improving quality of life. With the clear benefit of both elective total hip arthroplasty (THA) and total knee arthroplasty (TKA) being well documented [1,2], surgeons and patients often turn to these procedures as the treatment of choice when treating arthritic, fractured, or pathologic hip and knee joints. However, although surgeons must prepare for an increasing rate of joint arthroplasty procedures in the future [3–5], they must continue to remain wary of the many complications associated with these surgeries. Although infection [6], significant blood loss [7,8], risk of dislocation [9], and pulmonary emboli [10] are all possible post-operatively and cost-heavy to treat [11], all healthcare providers must monitor for and guard against hypotension [12] leading to acute kidney injury (AKI) [13] before, during, and after surgery due to its direct correlation with increased morbidity and mortality [14].

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In 2004, the Acute Dialysis Quality Initiative workgroup identified a staging system for AKI. Per the Risk, Injury, Failure, Loss of Kidney Function, and End-stage Kidney Disease criteria (based on risk of renal dysfunction, injury to the kidney, failure or loss of kidney function, and end-stage kidney disease), AKI is staged based on estimated glomerular filtration rate (eGFR) decrease, serum creatinine increase, and degree of oliguria [15,16]. A similarly effective staging system, the Kidney Disease Improving Global Outcomes criteria, defines kidney injury severity based on creatinine levels and urine output [17,18]. Considering an incidence rate of less than 2% after joint replacement surgery [19,20] but as high as 9% when all orthopedic cases, including emergent procedures [21], are included, healthcare providers must constantly be evaluating patients for risk factors that can lead to eventually kidney injury.

Workup of suspected kidney injury includes a thorough history, physical examination, and a laboratory evaluation that includes urinalysis, complete blood count, serum creatinine, and fractional excretion of sodium. Pre-operatively, surgeons must identify comorbidities that increase the chance of a patient developing AKI. Higher body mass index (BMI), diabetes mellitus, peripheral vascular disease [12], increased age [22], congestive heart failure, and hepatic failure [23] are only a few of the risk factors that have been independently linked to increased chances of eventual kidney injury. Patients needing radiographic contrast agents for imaging as well as those taking nephrotoxic medications or antibiotics must all be identified and undergo preventative measures before undergoing surgery.

Peri-operatively, decreased blood pressure, significant blood loss, and other signs of hypotension must be promptly identified and treated due to its direct correlation with increased rates of AKI [23]. Studies have shown that a mean arterial pressure (MAP) less than 60 mm Hg for 20 minutes or less than 55 mm Hg for 10 minutes has been linked with increased risk of AKI [24]. Although controlled hypotension [25,26] is a common practice during many procedures, care must be taken not to under-perfuse the kidney. Even though decreased urine output can be an indicator of abnormal kidney function or even total body volume depletion, it can occur normally during surgery and should not be independently treated without other signs of hypotension [27]. True hypotension should be treated immediately using a combination of blood transfusions, vasopressors, and fluids [28]. Multiple studies also document the efficacy of utilizing either intravenous or topical tranexamic acid, a synthetic anti-fibrinolytic agent, pre-operatively or post-operatively to decrease blood loss and ultimately hypotension [29–32]. Post-operatively, patients should be constantly monitored for hypotension and possible AKI using the markers detailed above. By reducing operative time, tourniquet time, and blood loss while closely monitoring vitals, oxyhemoglobin saturation, and urine output, surgeons and nurses can protect high-risk patients from further post-operative complications [13].

When critically analyzing our hospital system's rate of hypotension and AKI after TJA, an incidence rate of 14.54% and 6.02% was identified, respectively. Compared to similar local teaching hospitals with 400-500 beds (7.17%, 2.03%) as well as national averages (2%, 3.3%) [9,19,20,33,34], our higher percentages pushed the need for a protocol-driven intervention to be implemented. We present this change in management and the change in rates they caused in post-operative hypotension, AKI, length of stay, re-admission, and mortality rates to effectively judge the success of our protocol. The authors hope this protocol and the resulting decrease in elective TJA complications will provide a springboard for similar protocols to be implemented in various hospitals nation-wide struggling with elective TJA complication rate.

Methods

This prospective protocol-driven interventional study was conducted at a suburban 480-bed tertiary teaching hospital. Study approval was obtained by our hospital's Institutional Review Board. All patients undergoing an elective THA or TKA by one of our multiple fellowship-trained orthopedic surgeons were included in the study. Patients who were deemed poor surgical candidates due to existing co-morbidities and thus not offered surgeries were excluded from the study. Patients who underwent joint replacement secondary to a fracture of native bone in an acute setting were also excluded. In December 2015, every joint replacement surgery performed by an orthopedic surgeon in the health network during the previous 12 months was reviewed. After determining complication rates and the need for a hospital-wide intervention, a surgical management protocol was implemented in March 2016. Patient charts were reviewed for demographic information and detailed reports of pre-operative medical history, peri-operative notes, and post-operative course. Of note, our hospital did implement an electronic medical record (EMR; Epic Systems, Verona, WI) in January 2016, switching all inpatient medical information from paper charts to electronic records. In July 2016, full EPIC support for our protocol was achieved.

Using a multi-disciplinary team approach put together by 2 anesthesiologists, 1 nephrologist, 1 cardiologist, 2 internal medicine hospitalists, and 1 orthopedic surgeon, an elective joint arthroplasty management protocol was developed. Based on previous joint replacement patient care management protocols [35,36] and recommendations for successful patient care published in the literature [37], the authors designed and implemented a protocol that detailed guidelines and action plans for pre-operative surgical clearance, intra-operative complication minimization, and post-operative clinical management. All staff members involved in patient care were educated regarding the practice.

Pre-operatively, all patients underwent a complete surgical risk assessment. This included a review of all past medical history and subsequent specialized surgical clearance based on any co-morbidities present. Patients also had routine laboratory work performed including hemoglobin A_1C (%), hemoglobin and hematocrit, serum blood urea nitrogen, creatinine, and eGFR. Patients with an eGFR less than 45 mL/min/1.73 m^2 were referred to a nephrologist for pre-operative risk assessment. Patients with an eGFR of 45-60 mL/min/1.73 m^2 were referred to their primary care physician for risk factor optimization. Those patients with an elevated hemoglobin A_1C above 7% were referred to endocrinology for medical optimization pre-operatively. Only patients who were cleared for surgery based on risk assessment were offered a joint replacement surgery and taken to the operating room. All patients also received pre-operative blood management supplementation consisting of 325 mg of ferrous sulfate twice daily, 1 mg of folic acid daily, and 500 mg of Vitamin C daily for 4-6 weeks from their last pre-operative visit up until the day before their surgery [38].

On the morning of surgery, patients were asked to hold all their anti-hypertensive medications other than beta-blockers. Non-steroidal anti-inflammatory drugs, such as celecoxib and ketorolac, were held if baseline creatinine levels were higher than 1.5 mg/dL due to increased risk of AKI. The preferred prophylactic antibiotic of choice was 2 g of ancef IV given 1 hour prior to incision, regardless of BMI [39]. If a patient had a documented history of allergies to cephalosporins or penicillin, the patient was then given a test dosage of 1 g followed by full administration if there was no visible reaction. However, if a true anaphylactic allergy was documented or observed, the patient was then given 600 mg of IV clindamycin or 1 g of vancomycin, depending on the discretion of the surgeon.