Abstract 2

Title: Implementation of a Web-based Learning Tutorial into an Anesthesiology Residency’s Chronic Pain Rotation Curriculum

Authors: Eric, M, Wise; Scott, W, Berry; Scott, A, Brancolini

Department: Department of Anesthesiology, University of Pittsburgh School of Medicine

Introduction: Web-based learning is becoming common in medical education curricula. An outpatient-based residency rotation faces the challenge of achieving knowledge gains in a busy clinical setting.

Hypothesis: Incorporating a set of web-based tutorials into a residency rotation’s curriculum will increase resident knowledge gains.

Methods: Residents were randomly assigned to control or study groups and took a standardized 30 question pre-test. The study group was then given 19 online tutorials focusing on chronic pain topics. At the end of the rotation, both groups took the same test and completed an evaluation survey. The study group’s post-test scores were compared to the control group’s scores. The changes in scores of the groups were compared. Means were calculated for the groups’ scores and analyzed with two-tailed t tests. Means were calculated for Likert Scores of 1-10 on the survey.

Results: The post-test scores of the study group were superior to those of the control group (24.5±2.7 vs. 20.5±1.9, p=0.01). Comparison of post-test and pre-test scores showed that the scores of the study group were higher than those of the control group (7.0±2.9 vs. 2.3±1.6, p=0.02). In the evaluation survey, the study group residents reported that the tutorials greatly increased both their knowledge (8.0±1.6) and clinical skills (7.8±1.0) in the rotation.

Conclusions: The addition of web-based learning tutorials to medical resident curricula has the potential to increase resident knowledge gains, and residents believe that they have the potential to greatly enhance their knowledge and clinical skills.

References:

Figure 1: A bar graph depicting pre- and post-test scores for both the control and study groups with standard deviation bars.
Abstract 63

"Incidence of new-onset atrial fibrillation in Surgical and Neurosurgical Intensive Care Units in a tertiary care academic center"


Penn State Department of Anesthesiology and Perioperative Medicine, Penn State Hershey Medical Center Hershey, PA

Introduction: Atrial fibrillation is one of the most common arrhythmias noted in patients admitted to intensive care units. Although long term risks of new onset atrial fibrillation associated with noncardiac surgery and sepsis were previously poorly elucidated, recent findings have garnered much renewed interest due to its validated association with significant long term risk of ischemic stroke and overall mortality.

Objective: In view of these observations, we sought to investigate the incidence of atrial fibrillation in the surgical and neurosurgical intensive care units in a tertiary care academic center and evaluate the eligibility of those patients for long term anticoagulation therapy based on the stratification of their risk factors for thromboembolism using CHA2DS2-VASc scores.

Methods: A retrospective chart analysis was conducted to identify all patients between the ages of 18 and 100 who developed new-onset atrial fibrillation (based on ICD codes) in the surgical and neurosurgical intensive care units in our medical center from January 2009 to March 2015. Additional diagnoses for all patients meeting the above criteria were also obtained in order to calculate CHA2DS2-VASc scores for each. Patients who had been diagnosed with atrial fibrillation prior to admission were excluded. The total number of admissions to the two intensive care units was also obtained from hospital admissions data in order to determine incidence of new-onset atrial fibrillation.

Results: We identified 25,787 unique admissions to the surgical and neurosurgical intensive care units at Penn State Hershey Medical Center between the dates of 1 January 2009 and 15 March 2015. Of those patients, 3,208 (12.4%) developed atrial fibrillation during their ICU stay; however, 2,817 (10.9%) had prior diagnoses of atrial fibrillation, leaving 391 (1.5%) cases of new-onset atrial fibrillation over a period of approximately 6 years.

Of those patients, 22 (5.6%) had CHA2DS2-VASc scores of 0, 32 (8.2%) had CHA2DS2-VASc scores of 1, and 337 (86.2%) had CHA2DS2-VASc scores of 2 or greater. Of the group with scores > 2, 64 patients had a score of 2, 67 had a score of 3, 90 had a score of 4, 65 had a score of 5, 36 had a score of 6, 8 had a score of 7, 5 had a score of 8, and 2 had a score of 9.

Discussion: As reported in existing literature, we found the incidence of new onset atrial fibrillation to be significantly high in critically ill patients in a tertiary care academic center. We found there were a significant number of patients who had CHA2DS2-VASc scores high enough to warrant initiating anticoagulation therapy in order to minimize long term risk of ischemic stroke.

In light of our data and other findings in existing literature, we feel intensivists should endeavor to address long term management of atrial fibrillation in the ICU through initiation of anticoagulation therapy when appropriate and ensure establishment of follow up after discharge. As such, we plan to expand this study to evaluate whether or not patients who met criteria for anticoagulation were treated appropriately upon discharge.

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Abstract 71

Longer Duration of Hypotension is Associated with Worse Outcomes After Pediatric Cardiac Arrest

Elizabeth K. Laverriere, MD, MPH, Benjamin French, PhD, Sarah M. Sánchez, BA, Robert A. Berg, MD, Alexis A. Topjian, MD, MSCE

Introduction/Hypothesis:
Following resuscitation from pediatric cardiac arrest, a single episode of systolic hypotension within 6 hours of return of spontaneous circulation (ROSC) is associated with increased in-hospital mortality and worse neurologic outcome. We hypothesized that more severe and longer duration of post-resuscitation hypotension would be associated with worse outcomes following successful resuscitation from pediatric out-of-hospital cardiac arrest (OHCA).

Methods:
This retrospective cohort included children ≤ 18 years who received ≥ 2 minutes of CPR with ROSC > 20 minutes, admitted to a Pediatric Intensive Care Unit (PICU) after OHCA from November 2012 to June 2015. Hourly systolic blood pressures for the first 72 hours following ROSC were standardized for gender and age and dichotomized as hypotension (<5%ile) vs. absence of hypotension (>5%ile). Association of the proportion of measurements of hypotension within the first 6 and 72 hours after admission with survival to discharge was examined using multivariate logistic regression.

Results:
Sixty-one patients were eligible. Thirty-one percent (n=19) had at least one episode of hypotension. Fifty-seven percent (n=35) survived to discharge. Baseline characteristics were similar for the groups, with no significant differences in asystole/PEA (63% vs 52%), duration of CPR (15 vs 10 min), or number of doses of epinephrine (3 vs 1). Increased percentage of hypotensive measurements within the first 6 hours of ROSC was associated with a non-significant reduction in discharge survival (adjusted OR 0.85; 95%, CI [0.68, 1.06], p=0.14), however, within the first 72 hours of ROSC, increased percentage of hypotensive measurements was associated with a significant reduction in discharge survival (adjusted OR 0.70; 95% CI [0.50, 0.97], p=0.033). When the vasoactive-inotropic score was added to the multivariate model, there was no longer an association between hypotension and survival (adjusted OR 0.73; 95% CI 0.43, 1.22); p=0.23.

Conclusions:
In this small study of post-arrest hemodynamics, after controlling for potential confounders, longer duration of post-resuscitation hypotension was significantly associated with increased discharge mortality at 72 hours after pediatric OHCA. The association of hypotension with decreased discharge survival was attenuated by the use of vasopressors/inotropes in this cohort. Larger studies and prospective evaluation of the impact of targeted prevention of hypotension post-ROSC are needed.

References:
Abstract 82

Post Operative Pain Scores in Craniotomy Patients Who Received IV Acetaminophen Intraoperatively

Taryn M. Reichard, Selina Read, Arne Budde, Department of Anesthesiology & Perioperative Medicine, Milton S. Hershey Medical Center, Hershey PA

Introduction: The adequacy of postoperative analgesia is one of the most important factors that determines early hospital discharge and the patient’s ability to resume their normal activities. Postoperative pain management in craniotomy patients can be challenging; these patients have mild to moderate pain, an increased risk of postoperative nausea/vomiting and the need for frequent neurologic examinations. Currently, traditional postoperative approaches to pain control for patients undergoing craniotomy for tumor resection have often included mono-therapy with opioids. These are effective medications for pain management in multiple types of surgery, but their usefulness may be limited by their multiple side effects including, but not limited to cognitive impairment, respiratory depression, nausea, and vomiting. Due to these limitations, it is important to evaluate non-opioid medications and adjuncts for postoperative pain control, such as intraoperative IV acetaminophen.

Objective: The objective of this study was to determine if intra-operatively administered IV acetaminophen had an effect on postoperative pain scores and total postoperative opioid consumption in craniotomy patients. We hypothesized that the addition of intraoperative IV acetaminophen would result in lower postoperative pain scores, decreased opioid medication use and potentially fewer side effects such as postoperative nausea/vomiting and sedation.

Methods: A retrospective chart review was performed for patients who received traditional intraoperative pain control with opioids and those who received traditional medications plus intraoperative IV acetaminophen. Pain scores and total opioid consumption was recorded for the first 6 hours in the postoperative period. For statistical analysis, the mean pain score was calculated for each patient through 120 and 360 minutes. A t-test was used to compare the differences in these pain scores. Subsequently, a chi-squared test was used to test for differences in treatment of nausea/vomiting between the two groups.

Results: 450 patients who underwent elective, non-emergent craniotomy from January 2008-January 31, 2015; 340 received traditional intraoperative pain control (opioid only) and 110 patients received traditional medications plus intraoperative IV acetaminophen. No significant differences in mean pain scores were found within the first 6 hours post-operatively between the 2 groups. The mean pain score for the acetaminophen group after 120 minutes was 3.0, in comparison to the group that did not receive acetaminophen who had a mean score of 3.2 (p=0.64). At 360 minutes, the acetaminophen group had a mean pain score of 3.1, while the group that did not receive acetaminophen had a mean score of 3.1 (p=0.70). We are currently continuing to analyze the 110 patients who received intraoperative IV Acetaminophen to determine whether post-operative opioid consumption differed between the groups.

Discussion: Our preliminary analysis suggests that intra-operative IV acetaminophen administration may not have a significant impact on pain management in the immediate postoperative period for patients who had a non-emergent, elective craniotomy. IV Acetaminophen is a relatively safe medication and has been implemented in the multimodal approach to analgesia for numerous different surgical procedures. Due to the retrospective nature of this study, we would recommend a prospective study in the future to further examine the use of intraoperative IV acetaminophen in regards to post-operative pain scores and opioid consumption.

References:
A Randomized Controlled Trial Comparing the Adductor Canal Catheter (ACC) and Intra-articular Catheter (IAC) following Primary Total Knee Arthroplasty

Marc W. Kaufmann, D.O., David H. Beausang, M.D., John-Paul J. Pozek, M.D., John T. Wenzel, M.D., Eric S. Schwenk, M.D., Marc C. Torjman, Ph.D., Jaime L. Baratta, M.D., Eugene R. Viscusi, M.D.
Anesthesiology, Thomas Jefferson University Hospital, Philadelphia, PA, USA.

Background: Total knee arthroplasty (TKA) is associated with severe postoperative pain. Multimodal analgesia, including peripheral nerve blocks are recommended for postoperative pain relief. Adductor canal blockade for TKA reduces opioid consumption in the first 48 hours after surgery while decreasing incidence of quadriceps weakness that is seen in femoral nerve blockade. Perineural catheters offer the advantage of extended pain relief for up to 48 hours after surgery. Intra-articular catheters have been shown to be effective in patients undergoing TKA when compared to IV or intrathecal opioids while also preserving quadriceps strength.

Objective: Compare the efficacy of adductor canal catheters (ACC) and intra-articular catheters (IAC) in patients undergoing TKA.

Methods: After IRB approval, ninety-six subjects undergoing primary TKA were randomized to receive either an intraoperative IAC or postoperative ACC. The IAC group received a constant infusion of 0.5% bupivacaine at 4 ml/hr while the ACC group received 0.2% ropivacaine at 10 ml/hr. Primary outcome measured was patient’s pain rating using a numeric scale (0-10) elicited during their first goniometric assessment on postoperative day 1. Secondary outcomes measured were opioid consumption at 24 and 48 hours, length of stay, and patient satisfaction. PainDetect and WOMAC scores were also measured at baseline and at 4-6 weeks postop. Data analysis performed using Analysis of Variance, Student t-test, and Kruskal Wallis test, with a p-value < 0.05 considered significant.

Results: Of the ninety-six patients enrolled in this study, fifty were randomized to receive an ACC while forty-six were randomized to receive an IAC. No statistical difference existed between the two groups in respect to age, BMI, sedation used, safety, or time spent in the PACU. Oxycodeone consumption was reduced in the ACC group compared to the IAC group during the first 24 hours (Median 25.0;IQR 40 vs 32.5;IQR 30 mg, p = 0.057) postoperatively. Patients in the ACC group reported significantly lower numeric rating scale (1-10) prior to the first PT session on POD 1 (3.60±2.2 vs 4.38±2.4, p = 0.023). Satisfaction scores did not differ significantly between the two groups on POD 1 or POD 2 (p = 0.74 and 0.62). 9 ACC patients received boluses, average time to bolus 12.67 hours +/-3.84 (range 8-22).

Conclusion: Adequate pain relief following TKA is critical as it allows patients to mobilize earlier, aiding in physical therapy, patient satisfaction, and shorter hospital stays. ACC resulted in similar pain scores and patient satisfaction compared to the IAC. In addition, the ACC reduced oxycodone consumption at 24 and 48 hours. ACC affords the ability to bolus during the first 24 hours which may be especially important as we move toward 23 hour stays for TKA, thus enabling a bolus of the ACC prior to discharge home.

References:
Abstract 94

Training Anesthesia Residents to Manage Malignant Hyperthermia: Is Simulation Better than Lecture?

Natalia MartinezAcero MD, Thomas Verbeek MBChB, Verghese Cherian MD, Julia Caldwell MD

Department of Anesthesiology & Perioperative Medicine, Penn State Hershey Medical Center, Hershey, PA

Introduction: Malignant hyperthermia (MH) is a rare and potentially fatal event in patients undergoing general anesthesia. MH occurs in 1/100,000 patients in the US with a 4-20% mortality rate. It is imperative that anesthesia providers be prepared to recognize and manage a MH emergency, however, the majority of anesthesia providers have limited experience in MH despite the fact that response time is critical to patient outcome. The use of simulation for team training involving OR emergencies has been shown to improve response time and management of simulated patients. Thus, high-fidelity simulation could be a critical tool for training anesthesia providers in rare emergencies such as MH.

Hypothesis & Objectives: We aimed to develop a simulation-training scenario to educate anesthesia residents in the management of a MH crisis. Our hypothesis was that an anesthesia provider exposed to high-fidelity simulation training would have a better theoretical knowledge on MH and perform better when confronted with this emergency, when compared to a lecture on MH.

Methods: Twenty-three 1st and 2nd year anesthesia residents were enrolled in the study and randomized to 2 groups: Lecture (LG: n=13) and Simulation (SG: n=10). To evaluate the baseline knowledge on MH, all the participants were given a 10-question test. Residents from each group were further subdivided into groups of 3-4 residents each, to perform a high-fidelity simulated scenario of a patient in MH crisis. All performances were video-recorded and the times to complete each of 10 steps of management (recognizing MH, stopping volatile agents, calling for help, calling for dantrolene, notifying the surgeon, correct bolus dose of dantrolene, cooling the patient, inserting urinary catheter, sending lab work, and treating hyperkalemia) were annotated for each group. Immediately after the simulation, the SG participated in a debriefing session and feedback was given about their performance while those from the LG did not receive any such feedback. Six months later, the participants from the LG received a didactic lecture about MH by an anesthesia attending. All the participants were then asked to participate in the MH simulated scenario and their performance was evaluated and they were also given the knowledge test. The pre- and post- ‘intervention’ test scores and the performances in the simulation scenario were compared between the two groups.

Results: After the intervention (lecture or simulation debriefing session), theoretical knowledge improved in both groups (LG p= 0.004 and SG p <0.001). The pre-intervention test scores were comparable between both groups (p= 0.22). However, SG showed better scores than LG when the post-intervention test scores were compared (p=0.02). After the intervention, performance, measured as the time needed to complete all 10 steps of management was faster for SG, but it was not statistically different from LG (p = 0.14)

Conclusion: Despite the small sample size, this study suggests that high-fidelity simulation can be more effective than lecture to improve theoretical knowledge about MH and also tends to improve the response to a crisis. Perhaps, a high-fidelity simulation session after a lecture would reinforce the important points for the diagnosis and management of rare clinical conditions such as MH and should be included in the curriculum for training anesthesiology residents.

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Abstract 96

Decreased ventilator and mortality impact of paravertebral nerve catheters on outcome of trauma patients with multiple rib fractures: a retrospective analysis.

Schott NJ1, Pearce-Smith B2, Chelly J3, Ibinson J4, Sperry J5, Alarcon L6
1Resident, Department of Anesthesiology; 2Clinical Associate Professor, Department of Anesthesiology; 3Professor, Department of Anesthesiology and Orthopedic Surgery; 4Assistant Professor, Department of Anesthesiology; 5Assistant Professor, Department of Surgery and Critical Care Medicine; 6Associate Professor, Department of Surgery and Critical Care Medicine

Background: Multiple rib fractures (MFR) are associated with significant morbidity and mortality. Treatment includes controlling pain and optimizing oxygenation and ventilation. Optimizing pain control and minimizing complications is paramount in management.

Objective: We sought to compare outcomes of a high number of MRF patients treated with paravertebral nerve catheters (PVC) compared to standard patient controlled analgesia (PCA) medication.

Methods: A retrospective review was performed of trauma patients with MRF admitted between 2006-2013. Data collected included patient age, injury severity score (ISS), days of mechanical ventilation, ICU length of stay (LOS), total hospital LOS, and in-hospital mortality. Epidural catheters were not included in analysis for hospital preference as well as safety and hemodynamic stability concerns.

Results: 4640 total patients sustained MRF after blunt chest trauma. Of these, 460 patients met criteria to receive PVC for treatment. All-cause mortality was lower in patients treated with PVC (2.0% vs 6.1%, p<0.01). Duration of mechanical ventilation was shorter for PVC patients (0.51 ± 2.15 d vs 2.00 ± 5.5 d [mean± SD], p<0.01). ICU LOS was shorter for PVC patients (2.71 ±3.26 d vs 3.71± 7.35 d, p=0.04). Hospital LOS was not different between groups. After excluding patients with significant head, abdominal or pelvis injury (Abbreviated Injury Scale ≥4), in-hospital mortality remained lower for PVC patients (1.6% vs 3.4 %, p<0.01). Duration of mechanical ventilation was shorter for PVC patients (0.46 ± 2.19 d vs 1.17 ± 3.78 d, p < 0.01). However, ISS, ICU and hospital LOS were not different between groups.

Conclusions: In this large retrospective review, the use of PVC in patients with MRF is associated with a decrease in duration of mechanical ventilation and in-hospital mortality compared to PCA. These results suggest that PVC may be an effective and safe pain management modality in many patients with MRF.

References:
Abstract 99

TITLE: Incidence, risk factors, and diagnoses associated with hospital-based acute care within 7-days of outpatient arthroscopic shoulder surgery.

AUTHORS: David N. Flynn¹, Wai-Man Liu², Nabil Elkassabany¹, Jiabin Liu¹.

DEPARTMENT AND INSTITUTION: ¹Department of Anesthesiology and Critical Care, Hospital of the University of Pennsylvania, Philadelphia, PA. ²Research School of Finance, Actuarial Studies, and Applied Statistics, The Australian National University, Acton, Australia.

INTRODUCTION: The rate of hospital-based acute care (defined as hospital transfer at discharge, emergency department [ED] visit, or inpatient hospital [IP] admission) following outpatient surgery is gaining popularity as a quality metric for ambulatory surgery. We conducted a retrospective study to determine the 7-day rate of hospital-based acute care following outpatient shoulder arthroscopy. We also investigated associated risk factors, diagnoses, timing, and financial impact of these events.

METHODS: New York State healthcare cost and utilization project (HCUP) outpatient surgery, inpatient, and emergency databases were used to obtain all study data. Eligible patients included adults who underwent outpatient arthroscopic shoulder surgery from 2011-2013. Unique patient identifiers were used to link subjects found in the outpatient surgery database to IP admissions and ED visits within 7-days of surgery. ICD-9 diagnosis codes were used to determine comorbidities and reasons for seeking care. When possible, similar diagnoses were grouped into categories. The Deyo-Charlson comorbidity index (DCCI) was calculated for each patient to assess comorbidity burden. Multivariable logistic regression analysis was used to evaluate risk factors associated with hospital-based acute care.

RESULTS: The final cohort included 110,922 patients. 69 patients (0.06%) were discharged to an inpatient facility following surgery. 1,874 patients (1.7%) received acute care within 7 days of discharge (Table 1). Patients who received acute care after discharge were older, more likely to be female. There were 1,650 ED visits and 224 IP admissions. The most common reason for seeking care was musculoskeletal pain (Table 1). Median charges were $1,420 for ED visits and nearly $14,000 for IP admissions. Nearly half of the events (46%) occurred on the day of surgery or on post-operative day 1 (Figure 1). Risk factors for admission included age, general anesthesia, OR time >2 hours, comorbidity burden (DCCI score), and history of arrhythmia or stroke (Table 2).

CONCLUSION: The rate of hospital-based acute care following outpatient shoulder arthroscopy in our cohort was 1.7%. Acute care visits often occurred within one day of surgery. However, very few complications were anticipated at the time of discharge, reflected by the low rate of direct hospital transfer (0.06% of patients, approximately 4% of events). Regional anesthesia appears to have been protective, while general anesthesia was associated with increased risk of hospital-based acute care.

<table>
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<tr>
<th>Table 1: Incidence, charges, and diagnoses associated with IP admission or ED visit within 7 days of outpatient shoulder arthroscopy</th>
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<td><strong>N (%)</strong></td>
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<th>Table 2: Multivariate analysis of risk factors associated with requirement for IP admission or ED visit within 7-days of discharge</th>
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<td>OR time &gt;2 hrs</td>
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<td>CV risk</td>
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<td>Diabetes</td>
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<td>Stroke</td>
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Figure 1: Incidence of IP visit or ED visit within 7-days of surgery by post-procedural day
Abstract 101
Renal Outcomes with Intraoperative Hydroxyethyl Starch Used in Elective Hysterectomies

David Yui M.D., Jonathan Waters M.D.
Department of Anesthesiology, University of Pittsburgh

Introduction: Hydroxyethyl starch (HES), a synthetic colloid, is one of the most frequently used volume expanders and can assist in treating hypovolemia. However, low-molecular-weight HES has been shown to increase the risk of AKI in large randomized trials, mostly in critically ill patients1,2. Despite this, surgical patients in the ORs are typically given smaller amounts of hetastarch. There are limited literatures assessing HES effects on kidney function perioperatively. We performed this retrospective study to evaluate the association between intraoperative HES administration and postoperative kidney function after elective hysterectomies.

Objective: To demonstrate that hetastarch use intraoperatively for elective procedures does not increase risk of AKI when compared to other colloids such as albumin and even crystalloids.

Materials and Methods: We obtained data on adults who had hysterectomies at eight hospital sites of the system from 2012-2013. Specifically, these cases included laparoscopic total abdominal hysterectomies, total abdominal hysterectomies, laparoscopic supracervical hysterectomies, laparoscopic vaginal hysterectomies, and salpingo-oophorectomies. We excluded patients who had CKD, received blood transfusion intraoperatively, and those who did not have appropriate pre and post operative data for the objective of this study. We recorded baseline characteristics including ASA classification, BMI, HTN, CAD, CHF, COPD, Asthma, DMI/II, CVA, PVD, and CKD. Patients were divided into three groups based on volume expanders used intraoperatively: HES, 5% albumin, and crystalloids. We used the Acute Kidney Injury Network (AKIN) criteria for defining AKI. The numbers of cases were described with percentage. A chi-square test was performed to compare the incidences of AKI among HES, albumin, and crystalloid groups. A p value less than 0.05 was considered as statistically significant.

Results: Of the 440 adult patients (ages ranging from 28 to 90), 199 were excluded from the analysis (180 due to lack of perioperative data, 4 due to CKD, and 15 due to blood transfusion). A total of 241 patients underwent the final analysis. Of the 159 patients in the HES group, 23 patients (14.5%) developed AKI [17 (10.7%) in Stage 1, 6 (3.8%) in Stage 2]. Of the 37 patients in the albumin group, 6 patients (16.2%) developed AKI [3 (8.1%) in Stage 1, 2 (5.4%) in Stage 2, and 1 (2.7%) in Stage 3]. Of 45 patients in the crystalloid group, 10 patients (22.7%) developed AKI [5 (11.1%) in Stage 1, 3 (6.7%) ion Stage 2, and 2 (4.4%) in Stage 3]. These results demonstrate that there is no significant difference in AKI incidence between the groups. There were no in-house mortalities.

Discussion: Although HES use in the critically ill has been associated with acute kidney injury, there is no association between HES use intraoperatively and renal function when compared to 5% albumin and crystalloids. Kancir et al demonstrated hydroxyethyl starch during hip arthroplasty had no statistical significance on renal function3. The study measured urinary excretion of neutrophil gelatinase-associated lipocalin (u-NGAL), plasma creatinine, and urine albumin as outcomes. However, unlike this study, they compared HES vs isotonic saline and did not compare albumin. Interestingly, Kashy et al showed that dose-dependent renal toxicity was associated with Hextend in patients having noncardiac surgery4. Our study demonstrates that there is similar AKI incidence among HES, 5% albumin, and crystalloids post operatively. Compared to 5% albumin solution, use of HES could bring a significant cost savings, as 5% albumin is three times more expensive than HES.

References
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Abstract 102

**Title**: Oscillating fibers as a mode for active mixing in hollow fiber membrane oxygenators  
**Authors**: Adam J. D’Souza, Brian Frankowski, William Federspiel  
**Department and Institution**: Department of Anesthesiology, University of Pittsburgh Medical Center and McGowan Institute for Regenerative Medicine, University of Pittsburgh  
**Introduction**: Artificial lung devices are currently being developed as alternatives to mechanical ventilation in the treatment of acute or chronic respiratory failure. These devices function either to remove excess CO2 or provide physiologic oxygenation in addition to removing CO2. This is accomplished using a hollow fiber membrane, not unlike modern Cardiopulmonary Bypass (CPB) or Extracorporeal Membrane Oxygenation (ECMO). In order to design an artificial lung that is more portable and ultimately ambulatory, these devices must allow for more efficient mass transfer. This flux can be increased by altering kinetics at the blood-membrane interface. Methods include eliminating the boundary layer, increasing the degree of mixing, and raising blood velocity relative to the membrane [1].  
**Objective/Hypothesis**: Oscillating the membrane will increase flux and enhance gas exchange.  
**Methods**: An oxygenator module was fabricated with a surface area of 0.3m² available for gas exchange. On either side of the module were ports for gas entrance and exit as well as an acrylic peg that could be connected to a scotch yoke mechanism to provide oscillation. Silicon adhesive (Permatex) was used to secure two custom-made non-compliant polyurethane bellows (Centryco) to either side of the fiber bundle. The housing that surrounded the fiber bundle and bellows assembly was made from clear acrylic and featured two endcaps, secured on either side of the assembly using the same silicon adhesive.  
**In vitro Gas Exchange**: A flow loop was constructed for testing that consisted of a blood reservoir bag (MVR 1600, Medtronic), a centrifugal pump (Biomedicus BP-80, Medtronic), a commercial oxygenator (Monolyth, Sorin Biomedica), and the module prototype. Tubing (Tygon) connected all of these components in series. Sweep gas through the commercial oxygenator was a N2/CO2 mix adjusted with a flowmeter (Aalborg Instruments) to set the inlet conditions in accordance with the Association for the Advancement of Medical Devices (AAMI) standards [2]. The blood flowrate was measured using a flow probe (Transonic) and O2/CO2 partial pressures at the inlet and outlet of the device were measured using a blood gas analyzer (RapidLab 248, Siemens). Pure oxygen sweep gas flowed through the module fiber via a flowmeter (Fathom Technologies). A variety of oscillation frequencies at various stroke lengths were tested in random order with each measurement repeated twice.  
**Results**:  
![Figure 1: In vitro blood experiment comparing enhancement of oxygenation at various stroke lengths and frequencies compared to a non-oscillating control](image)

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**Conclusion/Discussion**: Oscillating the fiber bundle clearly enhances the oxygenation of blood flowing through the module prototype. Optimal enhancement occurs at an intermediate stroke length and frequency.  
**References**:  