Please join us for the

16th Annual Research Symposium

Wednesday June 12th, 6:45–11am
Potter Conference Room

Speakers

Dr. Vicki Rosen
“Role of endogenous BMP2 in the skeleton”

Dr. Scott Tromanhauser
“Research Study Design: Avoiding Friction, Headaches, and Delays”

Posters of NEBH research will be displayed in the hallway outside of Potter

*Coffee and refreshments provided*
Background: Major orthopedic surgery carries the risk of considerable intra-operative blood loss, which is associated with numerous complications including post-operative anemia. Allogeneic blood transfusions (ABT) used to treat post-operative anemia are not without risks. Therefore, blood management strategies are necessary to battle intra-operative blood loss, associated complications, and to reduce the occurrence of allogeneic blood transfusions.

Objective: The current study aims to evaluate whether using small bowl intra-operative cell salvage (ICS) in conjunction with Tranexamic acid (TXA) has additional effects on reducing blood loss and preventing subsequent postoperative ABT among patients undergoing primary total hip arthroplasty (THA).

Methods: Using an institutional database, 1171 cases of THA performed between May 2015 and January 2016 were identified and retrospectively reviewed. Subjects were separated into two groups, those who received TXA only (n=323) and those who received TXA-ICS combined treatment (n=848). Demographic, comorbidity, laboratory, and surgical data were collected. Calculated blood loss, post-operative ABT, and post-operative blood transfusions were assessed using logistic regression to calculate odds ratios (OR) and 95% confidence intervals (CI). Drop in hematocrit (HCT) was assessed using linear regression. Multivariable models adjusted for intra-operative blood transfusions, pre-operative autologous blood donation, anticoagulation medications, sex, and body mass index.

Results: After adjusting for pre-operative autologous blood donation and type of post-operative anticoagulation medication used, the likelihood of receiving a post-operative ABT was similar for the combined group relative to the TXA-only group (OR=0.63; 95% CI: 0.26, 1.54). The likelihood of receiving any post-operative blood transfusion was also similar between the two groups (OR=1.13; 95% CI: 0.63, 2.01). After additionally adjusting for sex, BMI, and any transfusion prior to the lowest HCT measurement recorded, the likelihood of losing ≥33% of baseline blood volume was also similar for both groups (OR=0.92; 95% CI: 0.65, 1.30). Lastly, the addition of treatment group in the linear model did not add explanatory value above and beyond the pre-operative HCT level (R² = 0.117, R² = 0.118 respectively).

Conclusion: The current study observed no added benefit of combined TXA-ICS treatment relative to TXA alone on preventing blood loss or post-operative ABT among patients undergoing primary THA.
Depression of Vitamin D Levels after Adult Primary Posterior Spinal Fusion. Are We Adding Insult to Injury?

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**Background:** Vitamin D is a steroid hormone metabolized to its active form in the presence of parathyroid hormone in the kidney. It is essential in the process of bone formation which in turn is vital for achieving spinal arthrodesis. Previous studies have indicated that 43% of patients who undergo orthopedic surgery are vitamin D deficient (Bogunovic et al. 2010). Low vitamin D levels and increased inflammatory markers have been found following total knee arthroplasty (Henriksen et al 2013). Studies suggest that spinal fusion patients presenting with vitamin D deficiency achieved lower fusion rates and had higher rates of recurrent persistent back pain compared with patients with normal vitamin D levels (Rodriguez and Gromelski 2013). If patients are deficient in vitamin D preoperatively and their levels decrease postoperatively, do they ever attain the preoperative baseline and, if not, does this have an effect on successful spinal fusion? No large prospective study has been published that measures changes in vitamin D levels immediately after surgical spinal fusion. We share this data as part of an ongoing study investigating the relationship between serum 25-hydroxyvitamin D 25(OH)D levels and spinal fusion outcomes 1 year after surgery.

**Methods:** 103 participants were enrolled in this prospective cohort study of patients undergoing one or two-level primary posterior lumbar spinal fusion (PSF) with four surgeons between 2016 and 2018. The current study describes a preliminary analysis of all patients who had serum 25(OH)D measured at baseline, postoperative day 1 (POD–1) and at a follow-up within six weeks after surgery (n=70, mean follow-up time=31.9 ± 20.0 days). Average age and BMI of participants were 64.1 ± 10.7 years and 28.7 ± 6.2 kg/m², respectively. Over half (54%) of patients were taking 25(OH)D at baseline, and were on average older (p=0.005) and more likely to be female (p=0.001). Median differences in 25(OH)D were calculated at each time point and tested by Wilcoxon signed rank test.

**Results:** Median 25(OH)D was 35.3 ng/mL at baseline (range, 9.5–95.0 ng/mL) and 27.8 ng/mL at POD–1 (range, 7.0–63.5 ng/mL). Median change in 25(OH)D from baseline to POD–1 was –7.1 ng/mL or –20.9% (p<.0001). The majority (63%) of patients who had been taking vitamin D supplements at baseline had normal (>30ng/mL) levels at POD–1, while this was true for only 19% of patients who were not taking vitamin D (p=0.001).

**Discussion:** These results suggest that many patients who undergo PSF have inadequate 25(OH)D levels at the time of surgery. These results raise the question of whether fusion success could be affected by low vitamin D levels. Given the high prevalence of vitamin D insufficiency and deficiency in patients not taking supplements and those who were, we suggest that it might be beneficial to optimize 25(OH)D levels prior to surgery. Further research examining the effect of low 25(OH)D levels and 25(OH)D optimization on fusion success is recommended.
Identifying surgeon and institutional drivers of cost in total shoulder arthroplasty: a multicenter study

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Background: Despite rapid increases in the demand for total shoulder arthroplasty, there is a paucity of data describing cost trends. We aim to 1) describe variation in the cost of shoulder arthroplasty performed by different surgeons at multiple hospitals and 2) determine the driving factors of such variation.

Methods: Using time–driven activity–based costing (TDABC), we determined the cost of 1,723 shoulder arthroplasties performed by 16 different surgeons at four different high–volume institutions in the Midwestern and Northeastern United States between 2016 and 2018. Costs were broken down into supply costs (including implant price and consumables) and personnel costs. Cost parameters were compared to total cost for surgical episodes and case volume.

Results: Surgeons in the 90th percentile of cost were 1.73x more expensive than those in the 10th percentile. At the same points, implant cost varied by a factor of 1.86 and personnel costs by 1.81. Higher implant (p<0.001) and personnel (p<0.001) costs were both associated with higher total cost, but surgeon volume had no relationship with either cost parameter or total cost. Surgical volume per hospital varied by a factor of 4.6 and cost per case varied by a factor of 1.4. There did not appear to be any correlation between hospital case volume and inpatient costs (p=0.2860).

Conclusion: Variation in total costs was driven primarily by implant and personnel costs, but had no association with hospital or surgeon case volume. Similarly, there was no significant cost difference between the four high–volume institutions in this study.

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Influence of Soft Tissue Preservation in Total Hip Arthroplasty: A 16 Year Experience

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Background: Surgical technique in total hip arthroplasty (THA) has been a topic of debate over the last 50 years. Evidence-based studies are needed to compare one technique to another. This study investigated the outcome of the direct superior approach in primary THA as measured by patient perception of pain and recovery over a 16-year period.

Materials and Methods: We retrospectively reviewed a series of 3,357 consecutive patients who underwent primary THA by a single surgeon using the direct superior approach between 2001 and 2017. The surgical technique was modified twice during this 16-year period. The first modification (2007) consisted of piriformis tendon preservation. The second modification (2012) consisted of iliotibial band (ITB) preservation. These two modifications of the surgical technique created three different patient groups. A telephone interview regarding patient pain and recovery after each THA was conducted with 147 patients who had staged bilateral THA procedures wherein the surgical technique was modified between the first and second (contralateral) THA.

Results: Results show the addition of ITB preservation to capsular repair, with or without piriformis preservation, greatly improves the patient’s perception of pain and recovery, causing the majority of patients to prefer their ITB-preserving surgery of their ITB-sacrificing surgery. In addition, the dislocation rate over this 16-year period is 0.17%.

Conclusion: The direct superior approach to the hip results in excellent stability with a dislocation rate of 0.17%. The patient’s perception of pain and recovery is dramatically improved with preservation of the iliotibial band.
Inter–Professional Simulation in the Operating Room

Marci D. Kling, BSN, RN

- **Aim:** The purpose of this integrative review is to examine the impact inter–professional simulation has on OR staff and team dynamics.

- **Background:** The operating room (OR) remains a high risk area for sentinel events, with breakdown in communication identified as a root cause. Inter–professional simulation training is one educational approach to teaching nontechnical skills (NTS), such as communication and teamwork to OR teams.

- **Method:** A thorough search was conducted in CINAHL, MEDLINE, ERIC, and PubMed from January 2008 to December 2018 for keywords: communication, team training, operating room, and simulation. Inclusion criteria focused on NTS training amongst OR teams, with nurses actively participating in simulation. Filters included full text, English, and peer reviewed articles. A total of 12 research articles were reviewed, 8 quantitative and 4 mixed methods studies. Each article was appraised with the Hawker, Payne, Kerr, Hardey, and Powell (2002) critical appraisal tool.

- **Results:** Four themes emerged with improvements in: communication, role clarification, team cohesion, and changes in personal behaviors.

- **Conclusions:** Inter–professional simulation has a positive impact and improves NTS amongst OR teams. Formal debriefings are essential for effective communication. Team cohesion continues post–training. Reinforcement training is recommended to maintain speaking up behaviors. Simulation can break down hierarchal barriers in the OR. Interactive training increases confidence in handling crisis situations and inspires staff to change personal behaviors to provide safer patient care. Training enhances staff’s perception of the safety culture of their institution. These improvements lend themselves towards improving patient outcomes, yet further research is needed.
Lateralization and Decreased Neck–Shaft Angle Reduces Scapular Notching and Heterotopic Ossification

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- **Background:** Lateralization of the glenosphere to 6–10 mm in reverse shoulder arthroplasty (RSA) has been shown to mitigate scapular notching, but the effect on heterotopic ossification (HO) is yet to be described with a minimum of two-year follow-up.

- **Methods:** Retrospective review identified a consecutive series of 107 patients that underwent reverse shoulder arthroplasty between April 2013 and April 2016. During the study period, the surgeon switched from a more medialized design with a 2.5mm lateral center of rotation (COR) and a 155° neck shaft angle (NSA) to a 6 mm or 10 mm lateralized design with a 135° NSA. Preoperative and minimum two year postoperative American Shoulder and Elbow Surgeons Shoulder (ASES) score, visual analog scale for pain, Single Assessment Numeric Evaluation, and range of motion were collected. Postoperative radiographs were reviewed at a minimum of 2 years follow up to evaluate scapular notching and the development of heterotrophic ossification.

- **Results:** Patients with a more lateral COR implant were 72% less likely to develop HO than with a more medialized prosthesis. Among those patients with lateralized implants who did develop HO, a greater proportion demonstrated type I HO compared to patients with a more medial implant. Scapular notching was 85% less likely with a lateral COR compared to the medialized prosthesis. Patients with a more lateralized prosthesis demonstrated higher postoperative ASES score (p=0.001; 10 point difference) and VAS pain score (p=0.003; 0.7 point difference) which may meet criteria for clinical significance.

- **Conclusion:** An implant with a more laterally offset glenosphere and lower NSA may decrease the incidence and severity of postoperative HO and scapular notching.

- **Disclosure Statement:** A.J. has been a paid speaker for DJO Global, a designer for Ignite Orthopaedics, and has equity in Boston Outpatient Surgical Suites

- **Acknowledgement:** Samuel Golenbock is to be thanked for assistance with statistical analysis.
Purpose: Epidural steroid injection is a common procedure for treatment of low back pain with radiculopathy. Depo-Medrol® (Pfizer, methylprednisolone acetate), on formulation of particulate steroid, has come under scrutiny in the press, questioning its safety. Although catastrophic complications have been associated with paraspinal injection of particulate steroid, our data shows the formulation is safe when used via the midline interlaminar approach for lumbar epidural injections. We report our experience with this approach using Depo-Medrol, with the aim of evaluating its safety.

Materials and Methods: We retrospectively reviewed fluoroscopically guided interlaminar epidural lumbar spine injections at our institution. In the last 20 years, 31,353 fluoroscopically guided, interlaminar lumbar epidural steroid injections with particulate steroid were performed. Fluoroscopic images, reports, and patient records were reviewed for any significant related complications.

Results: Over 20 years, 31,353 patients underwent fluoroscopically guided interlaminar epidural steroid injection with particulate steroids. No documented significant complications related to particulate steroid administration were identified.

Conclusion: Fluoroscopically guided lumbar spine epidural steroid injection is a safe procedure when utilizing the interlaminar approach.
Background: Few studies have reported rates of morbidity and mortality (MM) for multilevel (3 or more) posterior spinal fusion (SPF). We aimed to determine the short-term and long-term outcomes among patients undergoing PSF at a specialty referral hospital. We hypothesized that rates of complications the study population would be lower than the US national average.

Methods: A retrospective chart review of patients who underwent multilevel PSF by an adult spinal deformity surgeon between 01/01/2013 and 12/31/2017 was performed. Patients were followed until 12/31/2018. We excluded patients with a cause of death unrelated to their procedure. Short-term complications included deep vein thrombosis, wound infection, pulmonary embolism, death, reintubation, cardiac arrest, sepsis, stroke, and myocardial infarction that occurred within 90 days of procedure. Long-term complications included sacroiliac (SI) joint pain, rod breakage, non-union, proximal junctional collapse (PJC), stretch irritation, re-admission, re-operation, and death.

Results: Of the 383 patients (median age 65.7, IQR 58.0–71.3) were included (Table 1). 40 patients had multiple stage PSF, 187 (48.8%) had previous spinal surgeries. The median duration of follow-up was 34.7 months (IQR 20.0–52.3). 331 patients (86.4%) had multilevel PSF. On average, 5.5 vertebrae were fused and 62.9% of patients had pelvic fixation. Median procedure time was 538.0 minutes (IQR 456.0–606.0) and median blood loss was 1,000 ml (IQR 700–1,500). Median length of stay was 6 days (IQR 5–7). The mortality rate of the study is 0%. Short- and long-term MM rates were 6.0% and 29.5%, respectively, with most of the MM were dehiscence (3.0%) for short term, and SI joint pain (18.0%) for long term. None of the patients developed deep wound infection, while superficial wound infection occurred in five patients. The median long-term MM occurred in 10.9 months (IQR 3.8–20.2). A total of 51 patients received reoperations (16.7%).

Conclusion: We found the patients who underwent PSF at a specialty referral hospital in the past 5 years and found lower than expected morbidity and mortality outcomes. The incidence of mortality and deep wound infection among the study population was below the national average. This study provides important clinical information both for surgical providers and patients.
Introduction: Historically, intra–operative dural tear management has included admitting patients for at least 24 hours after surgery, with the restriction to remain supine. More recently, surgeons have begun discharging some patients on the same day as their dural repair.

Objective: The purpose of this study is to determine the readmission rate of patients discharged on the day of their surgery after sustaining an intraoperative dural tear. We hypothesize that patients sent home the same day of surgery will not have a significantly greater readmission rate when compared to those admitted for postoperative dural tear management.

Methods: Our inclusion criteria were patients 18 years or older, scheduled for outpatient spinal surgery, who suffered a dural tear and subsequent repair intraoperatively. Patients were scheduled with an orthopedic or neurosurgeon at a single institution. Exclusion criteria were being scheduled to be admitted prior to the surgery taking place. 273 records were reviewed, 111 of which had sustained a dural tear and were scheduled to be discharged same day. Demographic and intraoperative details were collected for each case. Cases that were re–admitted within 30 days due to CSF–leak related symptoms were flagged. Risk Difference and Risk Ratios were calculated in order to assess this difference in risk of readmission for patients that were and were not admitted postoperatively.

Results: Patients admitted after dural repairs were more likely to be older (p=0.001), have a diagnosis of stenosis (vs herniated nucleus pulposus) (p=0.004), have had a laminectomy (vs a micro discectomy) (p=0.007), have been scheduled Monday–Thursday (p=0.004), and had surgery with a surgeon with a smaller yearly caseload (p=0.016). The risk difference at current practice was 46/1,000 (95% CI: –42, 135). There were 46 more readmissions per 1,000 operations among those who were admitted compared with those who were discharged same–day. The Risk Ratio was 2.20 (95%CI: 0.45, 10.88), meaning those admitted after surgery have 2.2 times the risk of readmission compared to those discharged same–day.

Conclusion: Sending patients home after intraoperative dural repairs may not increase their risk of readmission. Systemizing how a surgeon categorizes cases to discharge or admit based on age, diagnosis and procedure may allow more same day discharges to occur. Future research is needed to look at surgeon caseload as well at day of scheduled surgery in relation to readmission rate. Possible cost savings may be available with a decreased length of stay.
Survivorship of Pinnacle Ultamet Metal on Metal (MoM) Total Hip Arthroplasty (THA): Medium to long–term follow–up

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Introduction: MoM hip articulations in THA were created as advancement to the popular metal–on–polyethylene articulations, as an attempt to improve failure rates, allowing for larger femoral heads, increasing stability and range of motion. Revision for adverse reaction to metal debris (ARMD) remains a problem within the field of hip arthroplasty. It is unclear whether a connection exists between femoral head size, offset, neck length, and cup abduction angles in metal–on–metal (MoM) total hip arthroplasty (THA) implant systems.

Objective: We suspect that implant size and placement will affect chances of undergoing revision surgery.

Methods: From 2003 to 2008, 692 cases of MoM THA were completed by a single surgeon at our institution. All MoM implants were the Pinnacle Ultamet articulation. Patient demographics, implant details, and revision details were collected. Radiographs from follow–up were accessed to measure cup abduction angles and presence of osteolysis. Rate of revision was calculated in regards to femoral head size, offset, neck length, and cup abduction angles.

Results: 692 THAs were identified, with 78.6% of patients returning for an average follow–up of 9.2 ± 4.1 years; 27 underwent revision. Average time–to–revision was 7.2 ± 3.9 years. The overall revision rate was 5.4 revisions per 1,000 person–years; 3.0 revisions per 1,000 person–years ARMD. THAs with a neck length of 6–9mm had revisions at 2.57 times the rate (95% CI: 1.01, 6.54) relative to those with a neck length of 0mm. THAs with cup abduction angles of ≤40 degrees had revisions at 1.98 times the rate (95% CI: 0.92, 4.29) relative to those between 41–50 degrees. No statistically significant difference was detected in revision rates between implants of different offsets and head sizes.

Conclusion: MoM implant systems with longer necks and smaller cup abduction angles may lead to increased time–to–revision. Results from this study suggest a need for closer long term follow up of MoM total hip arthroplasty systems.

Acknowledgements: Samuel Golenbock is also to be thanked for assistance with statistical analysis.
Variation in the Cost of Care for Different Types of Joint Arthroplasty

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**Background:** Lower extremity arthroplasty constitutes the largest burden on healthcare spending of any Medicare diagnosis family. As demand for upper extremity arthroplasty continues to rise, understanding cost accounting for these procedures will also become important as payment models evolve. We aim to a) identify if variation exists in total cost for different types of joint arthroplasty, and b) if so, what cost parameters drive this variation.

**Methods:** The cost of an inpatient care episode for 22,215 total joint arthroplasties was calculated by implementing time-driven activity-based costing at a single institution between 2015–2018. Implant price, supply costs, personnel costs and length of stay for total knee (TKA), total hip (THA), total shoulder (TSA), reverse total shoulder (RSA), total elbow, and total ankle arthroplasty were analyzed with software developed by Avant-garde Health. Individual cost parameters were compared to total cost and volume. Proportions and percentages were used to ensure confidentiality of internal hospital cost data.

**Results:** TKA and THA were performed on an order-of-magnitude more frequently and correlated (p = 0.003) with lower average procedure cost and lower implant costs. Implant cost was associated (p=0.005) with higher total costs for all types of arthroplasty and represented on average 53.8% of the total cost for an inpatient care cycle (Figure 1). Supply costs showed greater variation than personnel costs, but did not correlate significantly with higher total costs, nor did length of stay.

**Conclusion:** Implant price was the primary contributor to total inpatient cost for all categories of total joint arthroplasty. Bargaining power for implant purchase price within our institution was only shown when procedure volume was an order-of-magnitude (TKA and THA) higher. As such, this trend may not extend beyond the institution level and does not necessarily imply that higher volume institutions for TSA and RSA have the ability to negotiate lower implant prices. This may be due to a lack of cost transparency.

**Disclosure Statement:** D.A.M. receives royalties from DePuy; A.J. is a paid consultant for DJO Global, a designer for Ignite Orthopaedics, and has equity in Boston Outpatient Surgical Suites.