In This Issue:

3  MOON Group Rising: 10 Years of Results — and the Road Ahead

6  Early Use of a Novel Magnetic Growing Rod for Early-Onset Scoliosis

8  Using Fluoroscopy for Acetabular Component Positioning in THA

11  Image of the Issue: US-Guided Hydrodissection to Treat Nerve Entrapment

12  Innovative Implants Bring New Revision Options in Total Elbow Arthroplasty

14  Transforming Periop Blood Management in TJA with Tranexamic Acid

16  Case: Osteosarcoma Requiring Hemipelvectomy in a Patient Refusing Blood Transfusion

18  Retirement Profile: Gordon R. Bell, MD
Dear Colleagues,

It’s not news that healthcare is becoming more and more of a team sport, but what are the teams and who are our teammates? At Cleveland Clinic, we answer those questions as broadly as possible and find good teammates wherever we can. This issue of Orthopaedic Insights is full of examples of how healthcare teams can be formed for the benefit of patients and the pursuit of healthcare value:

Teaming up across institutions. Our lead article (p. 3) presents an update from one of the premier multicenter collaborations in our specialty, the Multicenter Orthopaedic Outcomes Network (MOON) Group. As the group marks 10 years since its first publication, it illustrates how much a well-coordinated research collaboration can shape clinical practice — in this case for ACL tear reconstruction.

Teaming with industry. Two articles illustrate the potential benefits of judicious collaboration with industry. On p. 12, we review how an elbow arthroplasty system that one of our surgeons helped design has been addressing previously unmet needs. And on p. 6, we profile the case of one of the first young patients in the nation to receive a novel magnetic spinal growing rod for early-onset scoliosis. Placement of the innovative implant was facilitated by early training from the implant’s manufacturer.

Teaming with colleagues in other disciplines. On p. 14 we share promising results from a pilot study of a new blood management protocol for total joint arthroplasty developed after consulting with other surgical departments at Cleveland Clinic about similar protocols they had in place. And a related case study on p. 16 details how a multidisciplinary Cleveland Clinic team collaborated to creatively use tranexamic acid for a hemipelvectomy in a patient who refused blood transfusion for religious reasons.

Finally, I have my own team story to share. In March I was honored to be named President of Marymount Hospital, one of eight regional hospitals in the Cleveland Clinic health system. My charge is to maximize the hospital’s assets, including its personnel, its culture and its newly renovated OR. It’s likely that orthopaedics will be a central surgical focus at Marymount Hospital in a relatively short time.

I remain Chair of the Department of Orthopaedic Surgery until my successor is named, but this may be my last letter in Orthopaedic Insights. It has been a privilege to lead this department’s team of expert surgeons for seven years, and I am delighted to be continuing my sports medicine and arthroscopic knee surgery practice within the department — simply from a new home base. So I am blessed to be gaining a new team without leaving the one I’ve been proud to be part of for more than two decades.

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MOON Group: A Decade After Its First Publication, It’s Redefining What a Cohort Can Achieve

Changes in ACL Reconstruction Practice and Perspectives — and the Road Ahead

By Kurt P. Spindler, MD

Ten years have passed since the Multicenter Orthopaedic Outcomes Network (MOON) Group published its first paper on outcomes following surgical reconstruction for anterior cruciate ligament (ACL) tears. More than 40 papers later, this unprecedented undertaking in orthopaedic outcomes research continues to yield rich clinical insights.

Many of these insights are captured in a major review article in the March 2015 Journal of the American Academy of Orthopaedic Surgeons and sampled in the sidebar on p. 4. While these findings are prompting changes to orthopaedic practice, MOON’s most significant impact may well be the new benchmark it has set for conducting multicenter, multisurgeon research in orthopaedics.

MOON: A SHORT HISTORY

MOON traces its roots to the Vanderbilt Sports Medicine–Cleveland Clinic Foundation ACL Reconstruction Registry, which was founded in 1993 by me (when I was practicing at Vanderbilt Orthopaedic Institute) and two Cleveland Clinic colleagues — Richard Parker, MD, and Jack Andrish, MD.

This effort evolved into the creation of MOON in 2002 to enroll and longitudinally follow a cohort of patients undergoing surgical reconstruction for ACL tears. Its purpose: to collect and analyze data and establish predictive models for patient-specific outcomes.

The MOON Group has since expanded to a total of seven U.S. institutions (see sidebar on p. 5 for the full list) with 17 participating surgeons. By accumulating data from more than 3,500 ACL reconstructions to date, MOON has become the largest prospective longitudinal ACL reconstruction cohort in the United States.

MUCH MORE THAN A REGISTRY

MOON is more than a registry because it captures richer data, at a more granular level, and has a predetermined plan for using these data. Our goal since 2002 has been not just to collect baseline information, as a registry does, but to collect specific details about each patient’s demographics, injury, surgery and treatment — and then determine exactly how they factor into each patient’s outcome.

The key to achieving our goal is twofold:

• Collect sufficient follow-up data. This is something registries don’t typically have resources to pursue. Through follow-up questionnaires and selected patient visits, MOON has achieved an outstanding 80 percent follow-up rate at two and six years — with the promise of doing so up to 10 years as well. That tops the 50 and 60 percent rates that the much larger orthopaedic cohorts in Europe have achieved.

• Perform sophisticated multivariate analyses. We have relied on the expertise of biostatisticians to wade through the data complexities and analyze numerous risk factors.

THE KEY ROLE OF PATIENT-REPORTED OUTCOMES

Achieving an 80 percent follow-up rate has been paramount to MOON’s success. While patient follow-up may seem arduous
for some specialties, it is somewhat easier for orthopaedics, where effectiveness of treatment is predominantly gauged by pain relief and functional improvement, which can be accurately measured and validated by patients without the need for office visits.

For MOON, patients have reported outcomes using the following instruments:

- Knee Injury and Osteoarthritis Outcome Score (KOOS)
- Western Ontario and McMaster Universities (WOMAC) Osteoarthritis Index
- Marx Activity Rating Scale
- Medical Outcomes Study 36-Item Short Form (SF-36)
- International Knee Documentation Committee (IKDC) subjective knee evaluation form

These tools, which our specialty has been at the forefront of developing over the past decades, have enabled us to follow thousands of patients at low cost.

**WHAT'S NEXT FOR MOON?**

Despite the many insights from the more than 40 MOON papers to date, drawing definitive and comprehensive conclusions about what happens following ACL repair requires about a decade and a half of follow-up. So our next four years of data collection will be critical.

The MOON Group is currently applying for a grant to do 10-year follow-ups so we can further differentiate clinically successful and unsuccessful ACL reconstructions. More data will help us determine how to identify patients who may struggle with articular cartilage, meniscus and other collateral damage — and improve how we care for them.

**Clinical Insights Uncovered by MOON**

Here’s a sampling of notable findings gleaned from MOON to date:

- A constellation of patient-related factors influence outcome after ACL reconstruction, but those most associated with difficult rehabilitation and pain are smoking, elevated body mass index and lower educational level. Contrary to popular belief, incidence of bone bruising has not been shown to be a factor.

- Patients ages 10 to 19 have the highest ACL reconstruction failure rate, regardless of graft type.

- In high school- and college-age patients, allografts fail three times more often than autografts do. In light of this finding, many orthopaedic surgeons, including those in the MOON Group, are no longer using allografts in young patients.

- Repairs of meniscal injuries (in association with ACL tears) have a 14 percent failure rate. Yet patients with unrepaired meniscal tears report doing well at the same follow-up. More study is needed, but these early results may indicate that surgeons have been overtreating concomitant injuries.

- Gender is not a factor in risk of reinjury. Male and female patients who have torn an ACL are at equally high risk of repeat injury. Devising a strategy to prevent reinjury is important for all patients.

- Rehabilitation therapy can reduce the risk of repeat ACL tears by 40 to 60 percent. All patients should participate in training programs before returning to sports or resuming normal activity. Even after six to nine months of recovery, patients may still have neuromuscular deficiencies that require fine-tuning.

Data from 10-year follow-up will help us confirm whether radiographs really can predict osteoarthritis onset following ACL reconstruction.
For example, more than 10 percent of patients report painful osteoarthritis symptoms six years after ACL reconstruction. However, we have noticed potential arthritic changes on radiography much earlier — about 2.5 years after surgery — when the patient reports no pain. Data from 10-year follow-up will help us confirm whether radiographs really can predict osteoarthritis onset. Then we can potentially find ways to treat it earlier and modify patients’ outcomes.

Sweeping discoveries like this can come only from a collaborative approach and the study of cohort data. MOON surgeons, scientists, biostatisticians and other contributors are making significant improvements to orthopaedic medicine, providing physicians and patients with the highest-quality evidence for decision-making with the aim of improving ACL reconstruction outcomes.

REFERENCE


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Observations from Early Use of a Novel Magnetic Growing Rod for Early-Onset Scoliosis

By Ryan C. Goodwin, MD

Early-onset scoliosis remains one of the most therapeutically challenging entities encountered by the pediatric spine deformity surgeon. Children with severe deformities are often treated with some sort of early nonfusion intervention in an attempt to control the deformity until the chest cage grows large enough to accommodate the child’s growing lungs into adulthood.

THE BURDENS OF TRADITIONAL GROWING RODS

When intervention is required, it often consists of a growing rod construct designed to serve as an internal brace and support the corrected spine without fusion. Unfortunately, these static devices require repeat surgical lengthening roughly every six months to accommodate the child’s growing spine from the time of implantation until definitive fusion is accomplished once the chest cage has matured sufficiently — typically at age 10 to 12. This creates a huge burden of morbidity and cost.

ENTER THE MAGNETIC GROWING ROD

Fortunately, a less-burdensome alternative emerged with the 2014 FDA approval of a novel spine implant from Ellipse Technologies called the MAGEC® (Magnetic Expansion Control) System, which allows the growing rod construct to be lengthened nonsurgically in the office. Use of a magnetic actuator applied to the patient’s skin allows painless lengthening of the construct in the office at the frequency and magnitude desired by the surgeon.

This technology can significantly reduce the number of revision operations children with severe early-onset scoliosis require to treat their deformities. Its use is illustrated in the accompanying case example of a boy with infantile idiopathic scoliosis. He was the index case for placement of the magnetic growing rod at Cleveland Clinic and among the first U.S. recipients of the device following its FDA approval.

THE PROMISE OF REDUCED SUFFERING, LOWER COSTS

This device appears to be a safe alternative to traditional growing rod constructs and has the potential to avoid substantial morbidity and achieve considerable overall cost savings by significantly reducing the number of lengthening surgeries. Future studies on its more widespread use should shed light on the full impact this technology will have in this challenging patient population.

Dr. Goodwin at a follow-up visit with the recipient of the first magnetic growing rod at Cleveland Clinic. The top photo shows marking of the patient’s back to guide placement of the device’s magnetic actuator on the skin (lower photo) to enable painless lengthening of the rod in the office.
Case Study: The Magnetic Growing Rod in Action

The radiographs below (all posteroanterior views) are from the boy with infantile idiopathic scoliosis who received the first MAGEC magnetic spinal growing rod at Cleveland Clinic.

The patient initially had a traditional growing rod placed at age 2 years for a spinal deformity of greater than 90 degrees. He later developed an infection after one of several traditional rod-lengthening surgeries. Removal of all implants was required to eradicate the infection. When the patient was re-instrumented, the MAGEC device was used. He was 5 years old when it was placed in autumn 2014.

The patient has undergone three lengthenings of the device since then, all performed noninvasively in the office using the device’s magnetic actuator (see photos on p. 6). The correction has been maintained thus far, and the boy has reported no pain or neurologic complaints during or after the lengthenings.

The Patient’s Radiographic Profile Over Time

Top left. Image showing the patient’s severe early-onset scoliosis at age 2 years, prior to surgical intervention. Bracing and casting had failed to control the deformity.

Top right. Two years after placement of traditional growing rod instrumentation, prior to infection and the rod’s removal.

Bottom left. Following placement of the magnetic growing rod in autumn 2014.

Bottom right. After lengthening of the magnetic growing rod in the office. Note the expansion of the rod’s central barrel.

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Using Fluoroscopy to Improve Acetabular Component Positioning During Direct Anterior THA

Encouraging Results from a Large Retrospective Study

By Juan Suarez, MD

Acetabular component orientation affects the function and durability of total hip arthroplasty (THA). Malposition contributes to increased dislocation risk, impingement, accelerated polyethylene wear and early revision. At Cleveland Clinic Florida, we recently performed a retrospective analysis to evaluate the accuracy of acetabular component orientation using intraoperative fluoroscopy in direct anterior THA. We summarize our findings here and discuss why this aspect of THA is so central to positive patient outcomes.

OPTIMAL POSITION NEEDS TO REFLECT TRUE PELVIC TILT

Dislocation after THA remains a leading cause of revision surgery, and many studies have been performed to evaluate the optimal position of the acetabular component in THA. In their seminal paper, Lewinnek et al. defined target ranges for inclination and anteversion angles for cup placement (30° to 50° and 5° to 25°, respectively). These safe zones were described under ideal circumstances and do not reflect the variability and dynamic nature of the true pelvic orientation (pelvic tilt). This orientation is unique to each patient and influenced by spine deformities or sagittal plane balance.

For example, patients with significant lumbar lordosis will have anterior pelvic tilt, as illustrated in Figure 1. In contrast, patients with loss of lordosis, which can occur in cases of ankylosing spondylitis or following repeated spine surgeries, will present with posterior pelvic tilt, as shown in Figure 2. It has been calculated that every 1° of pelvic tilt leads to a functional correction of radiographic acetabular anteversion and inclination of roughly 0.7°. Therefore, the sole use of anatomic landmarks can lead to acetabular component malpositioning.

Valiant efforts at improving cup placement have focused on navigation and robotic systems that use anatomic landmarks and the anterior pelvic plane with minimal regard to the functional pelvic position. The two patient examples noted above represent the extreme scenarios of this concept. If anatomic landmarks are chosen for cup placement in these cases, the result will be excessive cup anteversion and inclination in the patient with loss of lordosis and cup retroversion and loss of inclination in the patient with excessive lumbar lordosis. In view of examples like this, we recommend using the pelvic tilt

Figure 1. Radiographs showing characteristic anterior pelvic tilt in a patient with significant lumbar lordosis.
We recommend using the pelvic tilt in the standing pelvis anteroposterior radiograph as a simple guide to the patient’s functional pelvic orientation.

We recommend using the pelvic tilt in the standing pelvis anteroposterior radiograph as a simple guide to the patient’s functional pelvic orientation.

A ROLE FOR INTRAOPERATIVE FLUOROSCOPY?
The intraoperative execution of this knowledge is not straightforward, as patient positioning in surgery affects our ability to recognize the true pelvic tilt. Pelvic orientation in the lateral decubitus position is unpredictable and influences implant alignment. The posterior approach, which requires a lateral decubitus position, remains the most popular for THA.

An advantage of the direct anterior approach to THA is that it facilitates the use of fluoroscopic imaging during surgery because the patient is in the supine position. Furthermore, the supine position provides less alteration of pelvic orientation during the surgical procedure. The image intensifier can be adjusted to recreate the patient’s true pelvic tilt intraoperatively and provide the surgeon real-time feedback during the preparation and implantation of the acetabular component.

Pelvic orientation is known to change during the course of the procedure as a result of retraction, and failure to recognize this may lead to component malposition. The C-arm can be adjusted accordingly in direct anterior THA to maintain the intended pelvic orientation throughout the procedure.

PUTTING INTRAOPERATIVE FLUOROSCOPY TO THE TEST
These considerations prompted us to undertake a retrospective radiographic analysis at Cleveland Clinic Florida to evaluate the accuracy of acetabular component orientation using intraoperative fluoroscopy in direct anterior THA. We hypothesized that fluoroscopy would be a useful tool to improve positioning of the component.

During the nearly four-year period analyzed (March 2010 through December 2013), 780 primary direct anterior THA surgeries were performed at Cleveland Clinic Florida. Across these 780 procedures, the mean inclination angle was 37.6° and the mean anteversion angle was 18.7°. Overall results were as follows:

- 718 cases (92.1 percent) fell within the targeted inclination range
- 723 (92.7 percent) fell within the targeted anteversion range
- 698 (89.5 percent) simultaneously fell within both targeted ranges

Figure 2. Radiographs showing characteristic posterior pelvic tilt in a patient with loss of lordosis.
The distribution of components simultaneously meeting target range criteria for both inclination and anteversion improved yearly for both surgeons performing these fluoroscopy-guided procedures, as detailed in the table.

**CONCLUSIONS AND NEXT STEPS**

Our goal was to evaluate the reproducibility of accurate acetabular component placement with the use of intraoperative fluoroscopy in direct anterior THA. The target ranges for inclination, anteversion and both were achieved in 92.1, 92.7 and 89.5 percent of cases, respectively. Our results demonstrate that the use of fluoroscopy during direct anterior THA is an effective tool for improving cup placement.

In addition, when examined yearly, the results show that both surgeons demonstrated improvements in their precision of component positioning, as explained by decreasing yearly standard deviation. We attribute the improvements to the learning curve associated with interpreting intraoperative fluoroscopy and to close, ongoing review of component placement tendencies.

Cleveland Clinic continues research efforts aimed at optimizing component positioning in THA. Our future efforts will be directed at correlating accuracy of component placement with functional outcomes and complications as well as recognizing the dynamic nature of the pelvic orientation and understanding its influence on total hip arthroplasty performance.

**REFERENCES**


**ABOUT THE AUTHOR**

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We attribute the surgeons’ improvements in positioning precision over time to the learning curve associated with interpreting intraoperative fluoroscopy and to ongoing review of component placement tendencies.
HISTORY AND PHYSICAL EXAM
A 34-year-old male healthcare worker presented with progressive bilateral dorsal-radial forearm and hand pain of one year’s duration. The pain was of burning character and in the distribution of the superficial branch of the radial nerve (SPN). The onset of symptoms correlated with a switch to electronic medical records at the patient’s workplace, requiring more typing. On physical examination, manual compression over the radial tunnel reproduced the patient’s symptoms. Forearm extensor strength was normal.

IMAGING
Initial imaging with MRI demonstrated no abnormal signal within the superficial branch of the radial nerve. However, subsequent ultrasound demonstrated a 3-cm segment of fascicular swelling with increased caliber of the SPN at the mid-forearm between the brachioradialis, extensor carpi radialis longus, and pronator teres muscles, where the nerve exits the deep fascia (Figure 1). The radial nerve at the radial tunnel and posterior interosseous nerve were normal in appearance.

INTERVENTION
Conservative management — including NSAIDs, splinting and physical/occupational therapy — failed to relieve the patient’s symptoms, so he elected to undergo an ultrasound-guided perineural steroid hydrodissection (Figure 2). After one month, the patient reported a 75 percent subjective improvement in symptoms with only mild modification of activity.

DISCUSSION
Entrapment of the SPN, classically referred to as Wartenberg syndrome, typically occurs secondary to friction between the mid-forearm muscle bellies and tendons as the nerve exits the deep fascia. The high spatial resolution of sonography allows for easier detection of subtle nerve abnormalities — such as fascicular swelling, epineural thickening and hyperemia — compared with MRI. Sonography also allows for real-time image-guided nerve therapies. Nerve hydrodissection displaces tendons and fascia surrounding the nerve by creating a perineural fluid plane, thus reducing friction. Concomitant steroid injection may help reduce scar formation.

Our institution often uses ultrasound-guided nerve hydrodissection before surgical intervention for a variety of nerve entrapment syndromes, including those involving branches of the ulnar, radial, median, femoral, saphenous, peroneal, posterior tibial, plantar and iliohypogastric nerves.

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Advances in Total Elbow Arthroplasty: Innovative Implants Bring New Revision Options

By Xavier Simcock, MD, and Peter J. Evans, MD, PhD

Recent success with elbow reconstruction following acute fracture in osteoporotic bone has led to a significant increase in rates of total elbow arthroplasty (TEA) — and subsequently in revision arthroplasty. While options for patients with failed TEA had long been limited, solutions for catastrophic implant failures are now more readily available with the recent development of the Comprehensive® Segmental Revision System (SRS) from Biomet.

THE ISSUES IN ELBOW ARTHROPLASTY

Nearly 600,000 upper extremity fractures occur in the U.S. every year.1 Although functional expectation after fracture care was previously limited by the patient’s healing potential, widespread popularization of acute fracture care with immediate arthroplasty has made an expectation of full functional recovery the norm for geriatric trauma patients.2 Overall patient satisfaction has also increased because fracture stabilization with arthroplasty allows immediate mobilization.3

Unfortunately, aseptic loosening remains a common problem in elective elbow arthroplasty, with reports ranging from 15 to 49 percent over long-term follow-up.4,5 Furthermore, the challenges of fracture fixation in an older population apply as well to patients undergoing arthroplasty for trauma. These patients have brittle osteoporotic bone, and an arthroplasty that fails often does so in a catastrophic manner, with significant bone loss.

The elbow provides significant anatomic challenges to the surgeon, which makes revision surgery even more difficult. There is limited bone available in the native elbow, let alone after prior fracture surgery or osteolysis for hardware failure. Thus, in the setting of revision surgery, the elbow is not forgiving to slight biomechanical or soft tissue misalignment.

AN EVOLUTION IN HARDWARE

Elbow arthroplasty systems previously had limited sizes and modularity available for implantation. In most cases, creating a successful revision joint required re-establishing the elbow bone stock with bone augmentation. Cancellous and cortical allografts were used, but these grafts (in addition to being costly) pose the same difficulties with osteosynthesis that are encountered with all fracture care in the geriatric population. In contrast, the Biomet SRS allows for extensive modular options to recreate humeral bone stock to support a stable elbow joint. It also was designed to maintain rotational stability in the humerus with the distal flange to limit micromotion and additional aseptic loosening.

The SRS has only recently been released, and while we continue to collect data on patients in whom we’ve used this system at Cleveland Clinic, our early results are encouraging (see sidebar for a representative case study). With the increasing use of TEA for arthritis and to treat trauma, the SRS will take on an expanded role in challenging revision cases.

REFERENCES

Case Study: New Solutions for Challenging Clinical Scenarios

A 63-year-old woman presented to Cleveland Clinic with pain and loss of function of the elbow in her dominant arm. Five years earlier, she had sustained a closed distal humerus fracture that was treated with plate fixation and off-label use of the Sorbie prosthesis (Wright Medical Technology) for hemiarthroplasty. She returned to work in a law office but had increasing pain in the affected elbow over time.

At the time of presentation, her radiographs demonstrated clear loosening of the prosthesis (Figure 1). She had a negative preoperative workup for infection and elected to proceed with revision TEA. Intraoperative photographs (Figure 2) showed the amount of bone resection necessary. She is now three months out from her operation and nearly back to full range of motion (Figure 3).

**Figure 1 (upper left).** Radiographs prior to revision TEA. Note the loosening of the prosthesis.

**Figure 2 (upper right).** Intraoperative photo from the revision TEA showing the degree of bone resection required.

**Figure 3 (lower left).** Radiographs three months after the revision TEA.

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Tranexamic Acid Can Transform Perioperative Blood Management in Total Joint Arthroplasty

By Joseph Styron, MD, PhD, and Carlos Higuera, MD

Total hip and knee arthroplasty (THA and TKA) are associated with significant intraoperative and postoperative blood loss. Although surgeons use a variety of surgical techniques and products to facilitate hemostasis, blood transfusions are still common. Cleveland Clinic's Department of Orthopedic Surgery implemented a preoperative blood management workflow in 2012 to reduce the need for blood transfusions. We report here results from our initial experience with the workflow and the rationale for its development.

THE BURDEN OF BLOOD TRANSFUSIONS

Blood transfusions in surgical patients carry significant hospital costs and patient risk. The annual financial burden of blood- and transfusion-related activities for all surgical patients has been reported to range from $1.62 million to $6.03 million per hospital.\(^1\) Moreover, postoperative transfusions are associated with a variety of complications, including infections, wound problems, transfusion reactions, coronary events, increased ventilator time, extended length of stay and in-hospital mortality.

At the beginning of 2012, approximately one-third of Cleveland Clinic’s primary and revision THA and TKA patients received postoperative transfusion of blood products. Researchers at other institutions have reported similar postoperative transfusion rates of 38.5 and 19.3 percent among THA and TKA patients, respectively.\(^2\)

PILOTING A BLOOD MANAGEMENT PROTOCOL

In 2012, a pilot group of high-volume THA and TKA surgeons in our department set out to reduce the requirement for postoperative blood transfusions in their patients by developing a comprehensive preoperative blood management (PBM) workflow. This simple and consistent workflow was based on blood management programs used by other departments at Cleveland Clinic. It involves the active diagnosis and treatment of preoperative anemia and other transfusion risk factors prior to performing a THA or TKA.

Coordinated by two full-time nurses, the workflow was initiated primarily via surgeon referral through a SmartSet (a group of orders and prompts commonly used together to document a specific condition) in the electronic medical record at a patient’s initial office visit. Additionally, the operating room schedule was screened by the blood management team to minimize the possibility of missing an eligible patient.

The workflow process began with patients undergoing a CBC and iron studies (ferritin, iron and total iron binding capacity). Preoperative anemia (defined as hemoglobin concentration ≤ 13 g/dL) triggered an evaluation of the patient’s iron studies and a thorough review of the medical history to identify any possible causes of anemia. Most patients treated had hemoglobin concentrations between 10 and 13 g/dL.

The transfusion rate declined from 33 percent in 2012 to 18 percent or less by late 2013 and early 2014, saving more than $1 million annually.

We complemented these strategies with intraoperative use of the antifibrinolytic agent tranexamic acid (TXA), which is administered intravenously or topically depending on the patient’s risk factors.\(^3\)

EFFECTS OF THE PROTOCOL IN FIRST 550 PATIENTS

To evaluate the effectiveness of the PBM protocol on decreasing the rate of blood transfusions among THA and TKA patients, we reviewed the records of 553 consecutive patients eligible for screening under the protocol. We then compared them with the records of 330 consecutive patients who underwent surgery before protocol implementation. The two cohorts were statistically similar in terms of demographics and comorbidities.

The protocol was successful at identifying patients most at risk of requiring a blood transfusion, with 17.7 percent of protocol patients undergoing some form of preoperative anemia...
treatment. Despite a small increase in preoperative hemoglobin as a result of the treatment, these patients still required blood transfusions at much higher rates than did their peers who did not require preoperative treatment ($P < .001$).

During implementation of the PBM protocol, intraoperative utilization of TXA (either topical or systemic) increased dramatically—from 0.6 percent of patients prior to implementation to 36.9 percent after implementation.

After multivariable analyses (adjusting for patient age, sex, preoperative treatment, type of surgery, length of surgery and postoperative deep venous thrombosis prophylaxis), it was the utilization of intraoperative TXA, not preoperative screening or treatment, that remained a significant predictor of decreased odds for requiring blood transfusion (odds ratio $= 0.289, P < .001$). Moreover, among patients who did require a transfusion, those treated with TXA required fewer units of blood products than did those not treated with TXA ($P < .010$).

The overall transfusion rate declined from 33 percent in 2012 to 18 percent or less by late 2013 and early 2014 (Figure). This represented savings of more than $1 million annually across the enterprise.

**THE BENEFITS OF CURBING TRANSFUSIONS**

Tremendous resources have been allocated to effectively screen patients preoperatively in an effort to reduce use of blood products following THA or TKA. Efforts to reduce transfusion rates are motivated by both patient safety concerns and financial considerations. Each unit of blood transfused has been estimated to cost hospitals between $522 and $1,183 in direct and indirect expenses.\(^1\) In addition, blood transfusions have been associated with increased risk of postoperative infection, poor physical function, increased use of rehabilitation facilities, longer hospital stays and increased mortality.

Our study found that preoperative optimization of patients may not be as effective as intraoperative utilization of TXA at reducing the need for blood transfusion following primary THA or TKA. Overall, this strategy has reduced transfusion rates while facilitating better preoperative screening, promoting more appropriate therapy and lowering overall treatment costs.

![Graph showing post-arthroplasty transfusion rates at Cleveland Clinic's main campus, by quarter.](image)

**REFERENCES**


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Case Study: When Osteosarcoma Requires Hemipelvectomy in a Patient Who Refuses Blood Transfusion

By Steven A. Lietman, MD, and Carlos Higuera, MD

CASE PRESENTATION
A 49-year-old man presented with femoral pain one year after undergoing resection of a proximal femoral osteosarcoma with a negative margin and ipsilateral proximal femoral replacement. The resection was followed by chemotherapy, and he initially fared well until he developed femoral pain that dramatically worsened prior to his current presentation. Radiographs and CT scans suggested recurrence of the osteosarcoma, which was confirmed by needle biopsy (Figure). Chest CT did not reveal metastasis.

Because the proximal femoral implant extended into the hip joint, an external hemipelvectomy was required to achieve an adequate negative margin. Hemipelvectomy was recommended to the patient, and after lengthy discussion of its benefits, risks and alternatives, he agreed to proceed with the procedure. Notably, however, he would not accept blood for religious reasons (he was a Jehovah’s Witness). A hematology consult was obtained, but the hematology team was unwilling to give erythropoietin based on the patient’s preoperative hematocrit of 45.8 percent. So the decision was made to intraoperatively administer the antifibrinolytic agent tranexamic acid instead.

SURGERY AND TRANEXAMIC ACID ADMINISTRATION
Tranexamic acid was administered intravenously at a dose of 1 gram at incision and then as a drip at 10 µg/kg/hr throughout the course of the surgery. The external hemipelvectomy was performed with a negative margin and a blood loss of approximately 450 mL. A cell saver was used and returned 150 mL of blood to the patient. Body temperature was maintained at 36 to 37°C. The wound was closed but developed drainage, and a negative pressure dressing was placed. Several negative pressure dressing changes followed, and the wound was closed without further complication.

The patient’s lowest hematocrit was 26.6 percent. During the period of negative pressure dressing changes, erythropoietin was given and his hematocrit improved. The patient fared well postoperatively, and his sutures were removed six weeks after surgery.
FIRST REPORTED HEMIPELVECTOMY WITH SOLE USE OF TRANEXAMIC ACID

Hemipelvectomy is an enormous operation that ordinarily involves major blood loss and multiple transfusions. This case, which has been submitted for publication, is the first to our knowledge in which tranexamic acid was used to decrease bleeding and avoid transfusion in a hemipelvectomy because of the patient's refusal to accept blood.

It is the second known report of a hemipelvectomy in a Jehovah’s Witness patient who would not accept blood. In the first report, it was erythropoietin support was used rather than tranexamic acid. In the case reported here, our hematology colleagues advised that the risks of preoperative erythropoietin use would outweigh the benefits, in view of the patient’s preoperative hematocrit of 45.8 percent.

Additionally, one of the authors (S.A.L.) has resected a telangiectatic osteosarcoma of the distal femur and reconstructed it with a distal femoral replacement in a Jehovah’s Witness patient, but this latter surgery was done under tourniquet. All these cases collectively illustrate that large surgeries can be done in patients who refuse transfusion for religious reasons, provided that careful preoperative planning takes place.

RESOURCEFULNESS IS THE RULE

It is unclear whether the tranexamic acid had an effect on bleeding during surgery in the case reported here. This synthetic amino acid has sometimes been associated with risk of seizures, although there were no such complications in this case. While further prospective examination of tranexamic acid in major ablative surgery is warranted, confidence in its general safety is bolstered by its growing use to reduce the need for blood transfusions in joint arthroplasty, as detailed in the preceding article (see pp. 14-15).

The resourceful approach to blood management in this case is characteristic of Cleveland Clinic’s Musculoskeletal Tumor Center, where a team of orthopaedic oncologists collaborates with expert colleagues from across Cleveland Clinic, including hematologists, radiation and medical oncologists, pathology subspecialists, and non-tumor colleagues in the Department of Orthopaedic Surgery. It is precisely for this type of challenging case — where a fresh, creative approach to clinical problem-solving is required — that we bring this collaborative, interdisciplinary ethic to our caregiving.

This and other rare cases collectively illustrate that major ablative surgeries can be done in patients who refuse transfusion for religious reasons, provided there is careful preoperative planning.

REFERENCE


ABOUT THE AUTHORS

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Retirement Profile:
A Salute to Stellar Spine Surgeon **Gordon R. Bell, MD**

A giant presence in Cleveland Clinic’s Department of Orthopaedic Surgery and Center for Spine Health for well over three decades retired earlier this year — but his legacy endures.

Spine surgeon Gordon R. Bell, MD, had been affiliated with Cleveland Clinic’s Department of Orthopaedic Surgery since starting his orthopaedic residency here in 1978, with just one year away for a fellowship in spinal surgery at the Pennsylvania Hospital in Philadelphia. He joined as a staff surgeon in 1983 and went on to contribute in diverse Department of Orthopaedic Surgery leadership roles, including:

- **Department Vice Chairman (1998-2006)**
- **Head of the Section of Spinal Surgery (1994-2014)**
- **Director of the Spine Fellowship Program (1985-1997)**

**BRIDGING ORTHOPAEDICS AND NEUROSURGERY**
In 2001 he took on a joint appointment in the Department of Neurological Surgery, where he played an integral role in formation of the Cleveland Clinic Spine Institute, which later became the Center for Spine Health in the Neurological Institute. Dr. Bell directed that center from 2009 through 2014.

His leadership has been instrumental to collaborations between Cleveland Clinic’s Neurological Institute and Orthopaedic & Rheumatologic Institute. One example is Cleveland Clinic’s lead role in the 2013-14 formation of the National Orthopaedic & Spine Alliance (NOSA), for which Dr. Bell served as a founding member of the quality and nominating committees.

**CLINICIAN, LEADER, SCHOLAR**
His clinical interests focused on degenerative conditions of the cervical and lumbar spine, athletic spinal injuries, and spinal tumors. He was consistently recognized by the physician peer-rating organization Best Doctors Inc.*, and he served as a longtime spine consultant to all three of Cleveland’s major professional sports teams.

Dr. Bell was a member of Cleveland Clinic’s Board of Governors from 1999 to 2003. He also held leadership roles in numerous professional societies, including the North American Spine Society, the International Society for the Study of the Lumbar Spine, the American Academy of Orthopaedic Surgeons and the American Orthopaedic Association. He was President of the Mid-America Orthopaedic Association in 2011-12. He is widely published and served as co-editor of two major spine textbooks, _The Spine_ and _The Lumbar Spine_.

**DR. BELL THROUGH THE EYES OF HIS COLLEAGUES**

“Beyond being a master spine surgeon, Gordon Bell has been a tireless example of integrity, professionalism and honesty to all who worked with him over his illustrious career. We will all miss working with him, but we will carry his hard work, compassion and dedication forward in the care of our patients. And his mentorship of hundreds of residents and fellows certainly endures both nationally and internationally well beyond his retirement from Cleveland Clinic.”

— Thomas E. Mroz, MD, Co-Director, Center for Spine Health, Departments of Orthopaedic and Neurological Surgery

“It has been a privilege to work with Gordon Bell for the past 12 years. He defines the phrase ‘a gentleman and a scholar’ and has been an excellent colleague and friend as well as an exemplary surgeon and administrator. His wisdom and collegiality will be missed. And so will his humor: It’s a real loss that the fellows and residents will no longer get to witness his celebrated ‘dura dance’ in the OR.”

— R. Douglas Orr, MD, Center for Spine Health and Department of Orthopaedic Surgery
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Cleveland Clinic is an integrated healthcare delivery system with local, national and international reach. At Cleveland Clinic, more than 3,000 physicians and researchers represent 120 medical specialties and subspecialties. We are a main campus, more than 80 northern Ohio outpatient locations (including 16 full-service family health centers), Cleveland Clinic Florida, Cleveland Clinic Lou Ruvo Center for Brain Health in Las Vegas, Cleveland Clinic Canada, Sheikh Khalifa Medical City and Cleveland Clinic Abu Dhabi.

In 2014, Cleveland Clinic was ranked one of America’s top four hospitals in U.S. News & World Report’s “Best Hospitals” survey. The survey ranks Cleveland Clinic among the nation’s top 10 hospitals in 13 specialty areas, and the top hospital in heart care (for the 20th consecutive year) and urologic care.
Orthopaedic Insights
A Physician Newsletter from the Department of Orthopaedic Surgery

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