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REVIEW ARTICLE/BRIEF REVIEW

Anesthesia for hip arthroscopy: a narrative review
Anesthésie pour arthroscopie de la hanche: une étude narrative

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Abstract

Purpose *Hip arthroscopy is a minimally invasive surgical procedure indicated for the treatment of specific hip disorders. In this narrative review, we aim to examine the key components in providing anesthesia for this procedure.*

Source *MEDLINE®, PubMed, and EMBASE™ databases were searched for peer-reviewed articles discussing the anesthetic management of patients undergoing hip arthroscopy.*

Principal findings *The primary anesthetic regimen used for hip arthroscopy should balance patient factors, preferences of the surgeon, and the demands of the procedure itself. Both general and neuraxial anesthetic techniques are well suited for this mostly ambulatory surgical procedure. There is a lack of current literature specifically comparing the benefits and risks of the two techniques in this setting. Postoperative pain management consists mainly of intravenous and oral opioids; however, a variety of regional anesthesia techniques, such as lumbar plexus block and fascia iliaca block, can be performed pre- or postoperatively. Overall, hip arthroscopy is safe, although positioning-related difficulties, extravasation of irrigation fluid, hypothermia, infections, and thromboembolic events are potential perioperative complications that warrant specific monitoring and prompt treatment.*

Conclusions *Until now, the anesthetic technique for hip arthroscopy has not been well studied. Thus, increasing emphasis should be directed towards examining relevant clinical outcomes that can better inform evidence-based decision-making in the anesthetic management of hip arthroscopy patients. In the meantime, awareness of potential complications and vigilant monitoring are paramount in providing safe anesthetic care for patients undergoing hip arthroscopy.*

Résumé

Objectif *L'arthroscopie de la hanche est une procédure chirurgicale peu invasive pour le traitement de troubles spécifiques de la hanche. Dans cette étude narrative, nous examinons les éléments clés de l'anesthésie pour cette procédure.*

Source *Des articles traitant de la prise en charge anesthésique des patients subissant une arthroscopie de la hanche ont été extraits des de données MEDLINE®, PubMed, et EMBASE™.*

Constatations principales *Le principal protocole anesthésique utilisé pour l'arthroscopie de la hanche doit établir un équilibre entre les facteurs liés au patient, les*

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préférences du chirurgien et les exigences de la procédure proprement dite. Les techniques anesthésiques générales et neuraxiales sont toutes deux bien adaptées à cette procédure chirurgicale principalement réalisée chez des patients ambulatoires. Il existe un manque de publications actuelles comparant spécifiquement les avantages et les risques des deux techniques dans ce cadre. La gestion de la douleur postopératoire fait essentiellement appel aux opioïdes par voies intraveineuse et orale; toutefois, différentes techniques d'anesthésie régionale, telles que le bloc lombaire et le bloc du fascia iliaca peuvent être réalisées en pré ou postopératoire. Globalement, l'arthroscopie de la hanche est sans danger, bien que des difficultés liées au positionnement du patient, l'extravasation du liquide d'irrigation, une hypothermie, des infections et des événements thromboemboliques constituent des complications périopératoires potentielles qui justifient une surveillance spécifique et un traitement rapide.

Conclusions *La technique anesthésique pour l'arthroscopie de la hanche n'a pas été bien étudiée. Par conséquent, un plus grand intérêt doit être porté à l'examen des résultats cliniques pertinents, afin de mieux éclairer les prises de décision basées sur des données probantes dans la gestion anesthésique des patients subissant une arthroscopie de la hanche. Dans le même temps, une sensibilisation aux complications potentielles et à la surveillance vigilante est primordiale pour assurer des soins anesthésiques sécuritaires à ces patients.*

Burman originally described arthroscopy of the hip in 1913.[1] Due to the limited indications for the procedure, hip arthroscopy did not start gaining popularity in North America until the late 1970s. In a landmark study, Gross described the arthroscopic assessment of hip pathology in pediatric patients with developmental hip dysplasia, slipped capital femoral epiphysis, and Perthes' disease.[2] Although a pediatric study, the same report concluded that the surgical techniques were similar for adults.[2] Since then, improvements in the arthroscopic technique, imaging capabilities, and surgical instruments have facilitated the arthroscopic treatment of hip pathology.

Though its origins are decades old, present-day hip arthroscopy is a relatively new procedure. As such, many anesthesiologists have had little or no exposure to the procedure in their training and subsequent clinical practice. Hip arthroscopy is now increasingly used in the treatment of both intra- and extra-articular hip pathology, including femoroacetabular impingement (FAI), acetabular labral tears, chondral defects, localized synovial disorders, hip capsular instability, as well as psoas tendon release.[3] By far, the majority of hip arthroscopy is performed to treat FAI along with the coexisting soft-tissue sequelae of the disorder.

Arthroscopy of the hip can be a challenging procedure, due in part to the deep location of the hip joint as well as the osseous and soft tissue constraints that surround it. With careful diagnostic evaluation and proper arthroscopic technique, hip arthroscopy can serve as an excellent diagnostic and therapeutic alternative to more invasive procedures.

In this narrative review, we discuss the indications for hip arthroscopy, including the preoperative assessment, anesthetic technique, analgesic adjuncts, as well as potential complications.

Sources

Using the keyword, "hip arthroscopy", we searched MEDLINE®, PubMed, and EMBASE™ databases for peer-reviewed English language articles discussing the anesthetic management of patients undergoing hip arthroscopy. We included all study types, including case reports and review articles. Eligibility for consideration was judged by consensus between two authors (H.Y. and L.B.) and was based on the title and abstract. Bibliographies of included articles were reviewed for relevant publications. Study quality was not formally assessed. Sixty-three articles were retrieved and 45 were reviewed by two of the authors (H.Y. and L.B.). Relevant textbook chapters were also reviewed.

Indications and contraindications

Currently, hip arthroscopy is the procedure of choice for the diagnosis and treatment of a variety of conditions affecting the hip, with FAI being the most common current indication. Table 1 outlines the most common indications for hip arthroscopy. Most impingement conditions are amenable to arthroscopic treatment, including labral tears, acetabular rim impingement, femoral cam-type impingement, as well as various chondral lesions.[4] Other isolated intra-articular abnormalities can also be addressed arthroscopically, such as ligamentum teres tears, loose bodies, or synovitis, though these are very rare in isolation. Furthermore, hip arthroscopy can provide excellent visualization of the quality of the cartilage in the central compartment of the hip and can be used in combination with major extra-articular corrections, including periacetabular osteotomy and proximal femoral osteotomy. Hip arthroscopy has also been used to treat benign intra-articular neoplasms, including synovial

Table 1 Indications for hip arthroscopy

1. Labral pathology
Femoral acetabular impingement (FAI)
Labral injuries
Acetabular dysplasia
2. Torn ligamentum teres
3. Chondral pathology
Chondral injury
Loose/foreign body retrieval
Focal avascular necrosis
Synovial chondromatosis
Chondrocalcinosis
Pigmented villonodular synovitis
4. Capsular pathology
Hip hypermobility/instability
Adhesive capsulitis
Synovitis
5. Diagnostic hip arthroscopy (unexplained hip pain, including pain following total hip replacement)
6. Extra-articular pathology
Trochanteric bursitis
Muscular pathology around the hip (gluteus medius, gluteus minimus, gluteus maximus, rectus femoris)
Iliopsoas tendonitis
Snapping hip
Nerve release around the hip joint

chondromatosis and pigmented villonodular synovitis.[5,6] In suspected cases of septic hip joint with negative joint aspiration, arthroscopy can establish a diagnosis by allowing direct sampling of joint fluid and synovial biopsy for subsequent analysis. At the same time, thorough irrigation and debridement of the joint can be performed.[7,8]

Numerous soft tissue disorders around the hip can also be managed via arthroscopic treatment, but these are far less common than impingement conditions. Coxa saltans, also known as snapping hip, can be caused by iliopsoas or iliotibial snapping and can be managed arthroscopically by iliotibial band or psoas release. Recalcitrant trochanteric bursitis can be treated by arthroscopic bursectomy. Several reports have shown that endoscopic abductor tendon repair provides pain relief and return of strength after abductor muscle tendinopathies, adding to the list of ever-expanding indications for arthroscopic surgery of the hip.[9,10]

Importantly, hip arthroscopy is contraindicated in patients with previous hip fusion, advanced osteoarthritis, open wounds or cellulitis, stress fractures in the femoral neck, severe dysplasia, avascular necrosis with collapse, significant heterotopic ossification, and morbid obesity.[11]

Preoperative evaluation

Due to the nature of hip pathology requiring the arthroscopy, patients undergoing hip arthroscopy are generally relatively young (< 45 yr old) and present with few other comorbidities. Therefore, an anesthesiologist's usual preoperative assessment on the day of surgery will usually suffice. Patients with significant known comorbidities may represent an indication for referral to a preanesthesia clinic.[12]

As with many other newer surgical procedures, more research is needed to determine the ideal anesthetic for hip arthroscopy. Comparisons between specific anesthetic modalities are lacking in studies addressing intraoperative management of these cases.

Surgical technique

Hip arthroscopy can be performed in the supine or lateral position. There are no specific indications for either position and the choice is largely dictated by surgeon preference. Based on our experience, however, it appears that approximately two-thirds of arthroscopies are performed in the supine position, with the remainder in the lateral position. The supine position allows for easier patient positioning, use of a standard fracture table, an operating room layout that is more ergonomic (Fig. 1), and optimal access for all arthroscopic portal placements. It also provides better access to the anterior hip.[13] Nevertheless, the approach to the hip in the lateral position is a straight line over the greater trochanter (Figs 2 and 3). The hip capsule is thinner laterally along the neck and the muscle envelope is not as developed; therefore, the arthroscope can generally be inserted more easily.[14] The lateral position could also be advantageous when accessing the hip in obese patients as gravity aids in the displacement of the overlying fatty tissue. In cases of significant anterior bony overcoverage, lateral positioning and entry to the hip might be indicated. While the lateral position is more time consuming to orchestrate, studies have shown that procedures performed laterally were completed faster than those performed with the patient in the supine position. This thereby negates any actual differences in total time required for the procedure.[15,16] Typical operating room setup is shown in Figs 1-4.

One of the intraoperative considerations common to many arthroscopy procedures is the risk of intra-articular bleeding leading to impairment in visualization. In our own experience, however, intra-articular bleeding is generally minimal during this procedure. That said, some degree of relative intraoperative hypotension is often used, and it is recommended to maintain the mean arterial pressure no higher than 65 mmHg in order to provide optimal

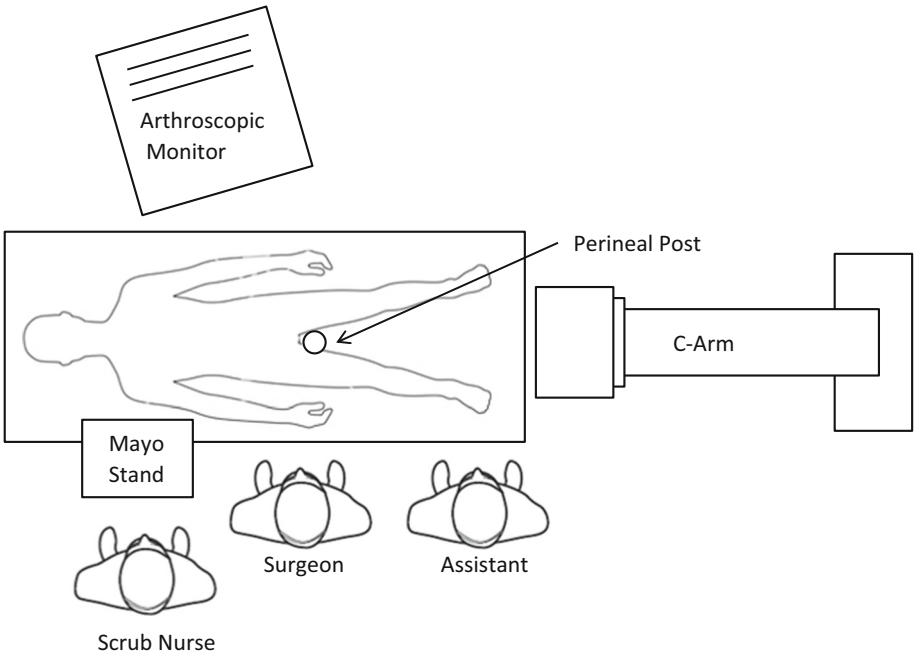

Fig. 1 Schematic diagram of the operating room setup for hip arthroscopy performed in the supine position. Notice that the operative hip is placed in extension with approximately 25° of abduction and with neutral rotation. The perineal post is lateralized to the operative side

conditions for visualization.[17] Perioperative adverse events associated with intraoperative hypotension (e.g., perioperative myocardial infarction and stroke) are uncommon in this patient population.[18,19] Intra-articular visualization is also aided by continuous irrigation of the joint space using a pump system that also allows for control and monitoring of exact pressure and flow and helps to limit periarticular fluid extravasation. Although it has been recommended to set the pump pressure to just above the patient's diastolic pressure to improve visualization in the joint, we use a much lower pressure (i.e, 30 mmHg) to prevent excessive swelling from fluid extravasation.[14] The pump pressure rarely needs to be increased during the operative procedure.

Adding diluted epinephrine (0.33 $\mu g \cdot mL^{-1}$) to the arthroscopic irrigation fluid is another technique to avoid intra-articular bleeding, as described in other types of arthroscopic surgeries.[20]

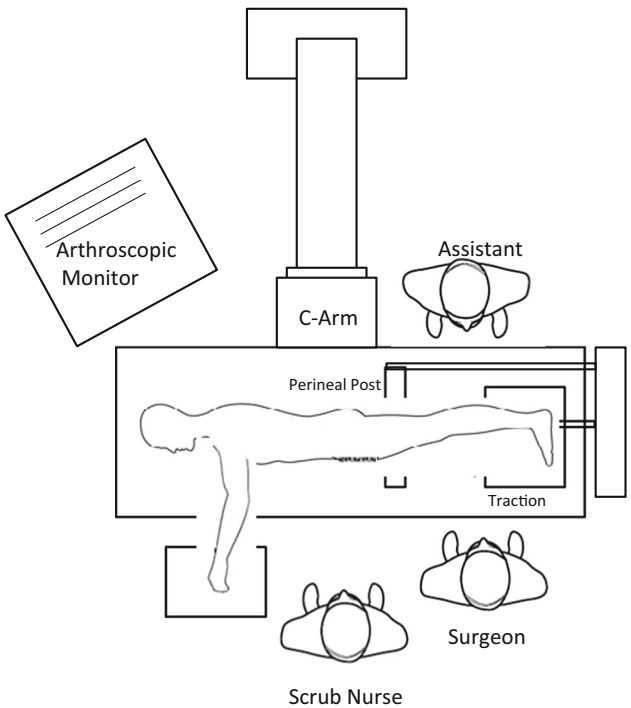

Fig. 2 Schematic diagram of the operating room setup for hip arthroscopy performed in the lateral position

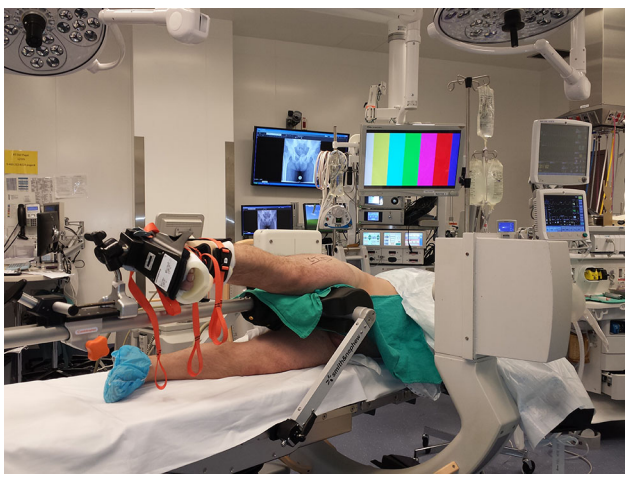

Fig. 3 A photograph of the operating room setup for hip arthroscopy in the lateral position. Notice the padded perineal post, the padded and reinforced feet, and the relative position of critical surgical and anesthetic equipment

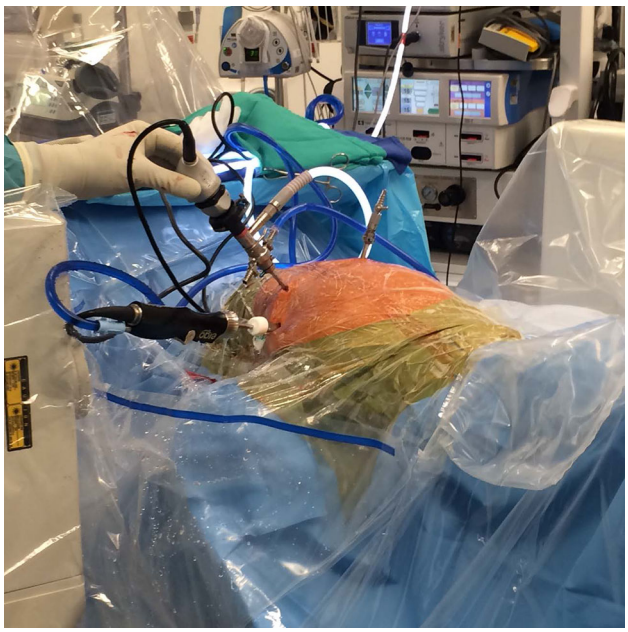

Fig. 4 A photograph of the operative setup and arthroscopic instrument insertion for hip arthroscopy in the lateral position

During hip arthroscopy, it is critical to achieve muscle relaxation and to eliminate any patient movement. Longitudinal traction is applied to separate the femoral head from the acetabulum by approximately 12-15 mm and thereby provide space to introduce the arthroscope and instruments. Transient femoral and sciatic neurapraxias are the most commonly reported complications associated with traction itself, whereas pudendal nerve palsy and scrotum or labial soft tissue injuries have been reported as a result of compression force exerted by the perineal post.[16] Muscle relaxation reduces the force required for hip traction and thus minimizes traction-related injuries.[16] General anesthesia with muscle relaxants usually achieves this condition, although neuraxial anesthesia techniques, such as spinal anesthesia with conscious sedation, may also be used depending on patient and physician preferences.[12-15] Table 2 summarizes the steps of the procedure and considerations for each step.

Anesthetic technique

General anesthesia

Typically, general anesthesia with muscle relaxants is used for hip arthroscopy.[12-15] General anesthesia allows rapid induction and allows for titration of the degree of muscle relaxation and hypnosis in response to changes in surgical approach, length of procedure, or other unforeseen circumstances. In addition, as patients undergoing hip arthroscopy are generally discharged on the day of their procedure, general anesthesia can potentially allow for earlier discharge compared with neuraxial anesthesia as it

Table 2 Procedural steps for hip arthroscopy

Steps	Considerations
1. Lateral Positioning	- Axillary roll for dependent axilla and hip positioners to support the pelvis
	- The foot of the operated leg is wrapped with padding and foot holder applied
	- Placement of a padded perineal post with outer diameter > 9 cm under operated leg
	- Minimal traction applied to support the operated leg
2. Preoperative *x-rays*	- Trial of joint distraction during fluoroscopy checks for distractibility of the joint. Failure to distract may necessitate greater force later during the procedure or need for capsulotomy. Trial of distraction also checks for security of the foot in the foot holder and allows for adjustment, since accidental release of distraction while the arthroscopic instruments are in the joint compartment can cause cartilage damage
3. Surgical prepping and draping	
4. Distraction application	- Recommended forces 25-50 lb for < 2 hr to avoid neurapraxias. If distraction force is not measured the endpoint should be 1-2 cm separation between the femoral head and acetabulum on fluoroscopic view
	- Need for deep muscle relaxation
5. Insertion of the portals(the number of portals is identical in supine and lateral positions)	- Anterior (proximity to lateral femoral cutaneous nerve, femoral nerve, and lateral circumflex femoral artery)
	- Anterolateral (proximity to superior gluteal nerve)
	- Posterolateral (proximity to sciatic nerve)
6. Arthroscopic examination	After intra-articular portion of the surgery is finished, distraction is released and periarticular work in the peripheral compartment can be performed without distraction concerns. Deep muscle relaxation is not required after release of distraction
7. Portal Closure	

avoids the need for waiting for resolution of the sensory and motor block associated with neuraxial blockade. This observation has been supported by studies comparing general and spinal anesthesia in other outpatient procedures such as knee arthroscopy and urological surgery.[21,22] Hip arthroscopy cases can vary in length, with some cases potentially lasting several hours, which may be at the limits of what an awake or sedated patient with a neuraxial technique may comfortably tolerate. Therefore, induction of general anesthesia at the beginning of the procedure can avoid the need and challenges of converting from spinal to general anesthesia in the lateral position.

Despite the flexibility and reliability of general anesthesia, spinal or epidural anesthesia may be used as the primary anesthetic technique for hip arthroscopy.[12-15] Both techniques will produce adequate muscle relaxation to allow traction and visualization of the hip joint, though sedation may be required for patient comfort. Compared with general anesthesia, neuraxial techniques have also been associated with 25% reduction in mean perioperative blood loss in hip arthroplasty, in part due to the decrease in venous pressure produced by the sympathetic blockade.[22,23] This is less relevant in the context of hip arthroscopy, however, as the procedure generally produces minimal blood loss. Neuraxial anesthesia in hip arthroplasty has been shown to decrease the incidence of deep vein thrombosis (DVT) by over 50% compared with general anesthesia and was unaffected by the choice of DVT prophylaxis.[24,25] Although these patients are not at the same degree of risk of DVT as total hip arthroplasty patients, studies are needed to show the ability of neuraxial anesthesia to reduce DVT in hip arthroscopy.[16] Lastly, using neuraxial anesthesia as the primary technique avoids the need for tracheal intubation and mechanical ventilation. This may reduce some of the early postoperative complications associated with general anesthesia, especially in high-risk patients, including short-term cognitive and pulmonary effects after general anesthesia.[26]

At present, there is a lack of studies directly comparing general anesthesia with neuraxial techniques in hip arthroscopy. Studies investigating combining general anesthesia with various regional techniques are underway.

Analgesic adjuncts in hip arthroscopy

Pain after hip arthroscopy is highly variable and can range from mild to severe.[27] It is most intense in the first 24 hr postoperatively. Edema of the quadriceps and hamstring

Table 3 Analgesia for hip arthroscopy

Reference	Sample size	Techniques used	Findings
Ward *et al.* 2012	40	Postoperative ultrasound-guided femoral nerve block (FNB) *vs* intravenous morphine. Both administered in PACU for postoperative pain score ≥ 7	- Decreased time to discharge from PACU (177 *vs* 216 min) - Decreased incidence of nausea (10% *vs* 70%) - Increased satisfaction with pain control (90% *vs* 25%)
Dold *et al.* 2014	96	Preoperative ultrasound-guided FNB *vs* control	- Decreased intraoperative analgesic use (2.72 mg morphine equivalent *vs* 8.05 mg) - Significantly lower pain scores compared with general anesthesia at 60 min (2.48 *vs* 3.68) - Significant reduction in morphine consumption in PACU (2.04 mg *vs* 4.00 mg) - No differences with regard to time to discharge from PACU or incidence of PONV
Xing *et al.* 2015	50	FNB with 0.5% bupivacaine *vs* normal saline	- Decreased morphine requirements intraoperatively (78.2 *vs* 94.5 mg of oral morphine equivalent) and at 48 hr postoperatively (10.9 *vs* 26.6 mg) - Significantly lower pain scores up to 6 hr postoperatively - 6 incidences of falls in FNB group
Krych *et al.* 2014	39	Fascia iliaca block	- High degree of satisfaction with postoperative pain control (33% satisfied and 67% very satisfied) - Low postoperative opioid consumption (on average 1.5 tablets of hydrocodone/acetaminophen 5/500 mg on postoperative day 1)

Table 3 continued

Reference	Sample size	Techniques used	Findings
Potter *et al.* 2014	107	Risk stratification into normal, at-risk, and distressed groups; fascia iliaca block provided postoperatively for inadequate pain control	- 36% of patients with normal distress level required fascia iliaca block compared with 60% of at-risk patients and 70% of distressed patients - Patients with high distress levels required 40% more intraoperative opioid (9.5 mg morphine equivalent *vs* 6.8mg)
Lee *et al.* 2008	2	L1 & L2 Paravertebral block	- Postoperative analgesia lasting 36-48 hr without need for rescue analgesics
Ilkhchoui *et al.* 2013	1	L1 & L2 Paravertebral block	- Postoperative analgesia lasting 24 hr without need for rescue analgesics
YaDeau *et al.* 2012	82	Lumbar plexus block *vs* control	- Reduced pain at rest in PACU by 0.9 points - No statistically significant differences in PACU analgesic usage, pain with movement, or patient satisfaction
Schroeder *et al.* 2013	236	Lumbar plexus block *vs* control	- Significant reduction in perioperative opioid administered (3 mg *vs* 5 mg of intravenous morphine equivalent) - Reduced pain scores in PACU compared with control (5.0 *vs* 5.3) - Reduced antiemetic consumption in PACU (32% *vs* 51%) - No difference in pain on postoperative day #1 - Increased total hospital time in lumbar plexus block group

PACU = postanesthesia care unit; PONV = postoperative nausea and vomiting

muscles, distension of the foot and pudendal region from the traction device, as well as soft tissue edema from fluid extravasation contribute to postoperative pain.[28] A retrospective review of 131 patients undergoing hip arthroscopy identified that the use of high arthroscopic fluid infusion pressure (> 80 mmHg) and procedures involving femoral chondro-ostectomy and labral repair were associated with higher pain scores on a numerical rating scale and higher opioid requirements intraoperatively and in the recovery room. The length of the procedure and the total amount of infusion fluid were not associated with pain outcomes.[29] Female patients were also found to have a higher level of postoperative pain.[27] A variety of pharmacologic and non-pharmacologic interventions have been assessed in the management of postoperative pain following hip arthroscopy. Table 3 summarizes studies of analgesic techniques used for this procedure.

In our institution, hip arthroscopy is an ambulatory surgery procedure. Patients are discharged home with instructions to take acetaminophen combined with codeine, oxycodone, or tramadol as needed, in addition to diclofenac 75 mg twice per day.

Therapeutic pain adjuncts

Femoral nerve block

Femoral nerve blocks are commonly placed for postoperative analgesia following operations on the thigh and knees and confer anesthesia to the anterior thigh, femur, and knee joint. Previously, femoral nerve blocks were shown to be beneficial for pain control and postoperative range of motion in patients undergoing total hip and total knee arthroplasties.[30,31] Several studies have addressed the utility of femoral nerve block for postoperative pain control following hip arthroscopy.

In a small randomized-controlled trial of forty patients undergoing hip arthroscopy, Ward *et al.* found that ultrasound-guided postoperative femoral nerve block with 0.25% bupivacaine 25 mL with 1:200,000 epinephrine led to shorter time to discharge from the postanesthesia care unit (PACU) and decreased the incidence of nausea compared with intravenous morphine.[32] More importantly, 90% of patients who received a femoral nerve block in this study reported being satisfied with their pain control *vs* only 25% of the patients receiving

intravenous morphine.[32] In a recent retrospective chart review of 108 hip arthroscopic surgery cases, Dold *et al.* compared groups undergoing general anesthesia alone with a group receiving general anesthesia with preoperative femoral nerve block. Patients who received preoperative femoral nerve blocks described decreased mean pain score at 60 min after admission to the PACU.[33] More importantly, patients in the general anesthesia only group received almost double the amount of morphine equivalents in the PACU. No difference was found between the two groups in terms of time to discharge from the PACU. Interestingly, two patients in the general anesthesia only group required overnight hospital admission due to uncontrolled postoperative pain, prompting a shift towards routine preoperative femoral nerve blocks at the authors' institution.[33] No incidents of falls were reported in this study following the femoral nerve blocks.

In a randomized triple-masked controlled trial, Xing *et al.* showed that a femoral nerve block may improve early pain control after hip arthroscopy. Due to an increased risk of falls, however, the authors did not recommend the routine use of this block for the outpatient procedure.[34]

If anesthesiologists perform the block postoperatively, they should be aware of anatomic changes in the inguinal region that occur following hip arthroscopy. In a case series of two patients, Davis *et al.* compared the sonographic images at the level of the inguinal crease of the operative and non-operative sides prior to performing a femoral nerve block for rescue analgesia after hip arthroscopy. Ultrasound identification of classic anatomical landmarks was complicated by extravasation of arthroscopy fluid, causing deep displacement of the femoral artery and femoral nerve. The tissue plane between the fascia iliaca and iliopsoas muscle was distended, and the femoral nerve appeared to be surrounded by fluid. Layering of large volumes of fluid deep to the fascia iliaca also has potential implications for nerve stimulator-guided blocks.[35]

Fascia iliaca block

The general indications for a fascia iliaca block are similar to those for a femoral nerve block and include regional anesthesia for thigh and knee surgery as well as postoperative pain management. Although the fascia iliaca block is not well studied in hip arthroscopy, a small prospective case series of thirty patients undergoing hip arthroscopy reported low opioid consumption and high levels of patient satisfaction with preoperative fascia iliaca block.[36] It should be highlighted, however, that all patients received multimodal oral analgesics, including acetaminophen, celecoxib, gabapentin, and oxycodone, making it difficult to discern the direct analgesic effect from the fascia iliaca block itself. The lack of a non-fascia iliaca block control group further limits the conclusions that can be drawn regarding the analgesic benefits of the fascia iliaca block in managing postoperative pain following hip arthroscopy.

To evaluate the effect of preoperative distress on the utilization of postoperative fascia iliaca block for rescue analgesia, Potter *et al*. administered the Distress and Risk Assessment Method questionnaire[37] to 107 patients undergoing hip arthroscopy before the surgery.[38] The authors showed that patients with higher preoperative psychological distress requested postoperative fascia iliaca block more frequently than patients who scored in the normal range. These patients had a higher initial visual analog scale pain score and showed greater improvement in pain score by the time of discharge from the PACU.[38]

Lumbar paravertebral block

Depending on the level of blockade and the volume of local anesthetic used, lumbar paravertebral block provides anesthesia to the ipsilateral dermatomes. Given the possibility of covering the lumbar dermatomes using this technique, its potential as a postoperative analgesic adjunct following hip arthroscopy has been relatively understudied, with only a few case reports available. In 2008, Lee *et al.* described two cases of L1-L2 paravertebral block before hip arthroscopy using 0.5% ropivacaine 5.0 mL at each level.[39] In both cases, the patients did not request any postoperative analgesia and were pain free after the procedure, for 36 hr in one case and for 48 hr in the other.[39] Ilkhchoui *et al.* describe similar success with preoperative L1 and L2 paravertebral block with 0.5% ropivacaine 5mL. In this case, the patient reported a score of 2/10 for pain 90 minutes after surgery while requiring no additional analgesics.[40]

Lumbar plexus block

Traditionally, lumbar plexus blocks have been used to provide anesthesia for surgery on the hip, thigh, and knee, including hip arthroscopy. In their prospective randomized-controlled trial, YaDeau *et al.* provided multimodal anesthesia during hip arthroscopy using combined spinal-epidural anesthesia with or without a single-shot lumbar plexus block (0.25% bupivacaine 30 mL with 1:200,000 epinephrine).[41] In this study, 42 patients receiving the block reported significantly lower resting pain scores while in the PACU, though no other significant differences were noted in patient satisfaction, antiemetic use, or quality of recovery scores.[41] Schroeder *et al.* reported similar results in their retrospective review of 118 patients, whereby lumbar plexus blocks improved immediate and peak PACU

pain scores, perioperative opioid administration, as well as antiemetic administration.[42] It was noted in this study, however, that pain on postoperative day one was similar between the two groups and total hospital stay was longer for patients who received the lumbar plexus block.[42]

Pharmacologic analgesic interventions

Current pharmacologic interventions for the management of postoperative pain following hip arthroscopy are identical to those used for most other similar orthopedic operations. Multimodal analgesia remains the cornerstone of treatment for postoperative pain and includes acetaminophen, nonsteroidal anti-inflammatory drugs (NSAIDs), and opioids. The added benefit of NSAIDs and cyclooxygenase-2 inhibitors is the potential for the prevention of heterotopic ossification in this patient population.[42] Indeed, in a recent retrospective study on arthroscopic management of FAI (n = 300), the prevalence of this condition was 33% among patients not receiving NSAID prophylaxis, with no case of heterotopic ossification in the treatment group. The majority of the patients in the treatment group received naproxen 500 mg twice a day for three weeks.[43]

While individual pharmacologic treatments for postoperative pain are not well studied, in a prospective randomized placebo-controlled study of patients (n = 53) undergoing hip arthroscopy under spinal anesthesia, preoperative administration of celecoxib 200 mg was found to lower pain scores at 12 and 24 hr postoperatively and to reduce opioid consumption by 41%, compared with the placebo group. This suggests that NSAIDs play an important role in the management of pain following hip arthroscopy.[44]

Complications of hip arthroscopy

The reported incidence of complications following hip arthroscopy varies from 1-1.6%.[16,45] The intra- and postoperative complications are summarized in Table 4.

Neurological injuries

The mechanisms for neurapraxias following hip arthroscopy include traction-related injuries of the femoral and sciatic nerves. Although the lateral femoral cutaneous nerve is also susceptible to traction injury, it is considered more vulnerable to direct injury from the skin knife or the instruments introduced through the anterior portal due to anatomical proximity.[16]

The lateral position has been associated with numerous non-operative limb nerve injuries.[16] Neurapraxia of the brachial plexus is one of the most common injuries, usually occurring as a result of prolonged pressure on the dependent contralateral axilla.[45] Radial nerve palsy is another common complication related to lateral decubitus patient positioning, where the non-dependent arm is placed on a lateral arm board. A combination of poor positioning, a lack of padding, and the patient's body settling in place are often responsible for the resulting compression of the radial nerve at the bend of the elbow.[46] Peroneal nerve injury of the contralateral leg has also been reported in the lateral position due to direct contact of the fibular head against the operating table.[46]

Compression-type injuries are associated with the use of a perineal post to provide countertraction. The pudendal nerve is primarily at risk, although one case of crural nerve palsy has also been reported.[16]

Fortunately, most nerve injuries are usually transient, and most patients will recover fully in approximately five to six months.[46] The injuries related to positioning could likely be prevented with proper padding as well as vigilant monitoring throughout the procedure. The risk of traction-type injuries might be reduced by limiting traction time to two hours and the traction force to 50 lbs, along with the use of a specialized distractor device equipped with a tensiometer.[16] Using a perineal post $\geq$ 9 cm in diameter and positioning it against the medial thigh rather than the groin crease usually helps in preventing pudendal nerve injury.[16] Laceration of the lateral femoral cutaneous nerve could be prevented with lateralized insertion of the anterior portal, therefore increasing the distance between the instrument and the nerve.[15]

Fluid extravasation

Irrigation fluid (usually 0.9% saline) can escape into various anatomical spaces adjacent to the surgical site during arthroscopy. Most cases of fluid extravasation occur during extracapsular procedures, such as psoas tendon release.[47-49] Capsular incisions during intracapsular arthroscopy or the presence of an acetabular fracture can increase the amount of fluid extravasation.[49-52] Irrigation fluid may also extravasate via the exposed iliopsoas sheath, resulting in accumulation of the fluid in the peritoneum and the retroperitoneum.[48] Intraperitoneal fluid extravasation and subsequent abdominal compartment syndrome represents one of the most severe complications following hip arthroscopy and is associated with abdominal distension, subcutaneous edema of the thigh, and hypothermia.[16,48] In a case report, Haupt *et al.* describe accumulation of 2-3 L of intraabdominal fluid following hip arthroscopy, with associated abdominal pain, distension, and neurologic symptoms resembling seizures.[50] Furthermore, cardiopulmonary arrest due to

Table 4 Complications following hip arthroscopy

Positioning-Related Complications	Etiology	Prevention/Management
Brachial plexus neurapraxia	Prolonged pressure on the axilla	Proper padding during surgery; early recognition following surgery, assessment by neurology, physiotherapy, pharmacologic adjuncts
Radial nerve palsy	Poor positioning and lack of padding around the elbow	
Peroneal nerve injury	Direct contact of fibular head with the operating table	
Surgical Complications		
Extravasation of irrigation liquid	Capsular incision, acetabular fracture, or extracapsular procedures, high pump pressure, long procedure	Avoidance of long surgical time, capsulotomies to be used sparingly, inflow fluid pressure 40-50 mmHg, monitoring fluid balance. Continuous perioperative monitoring; stop surgery if extravasation suspected, investigate via ultrasound or CT, and initiate appropriate treatment
Iatrogenic chondral and labral damage	Anterolateral portal insertion Inadequate traction	Careful surgical technique with portal insertion distraction $\geq$ 10 mm, followed by intra-articular saline injection to expand the intra-articular space
Hypothermia	Prolonged surgery time, low temperature of irrigation fluid	Warmed irrigation fluid, warming blanket, continuous perioperative temperature monitoring
Postoperative infection		Single-dose prophylactic antibiotic administration
Postoperative deep vein thrombosis		Early (same day) postoperative mobilization Intraoperative use of antithrombotic stockings on the contralateral extremity Pharmacological prophylaxis administered on an individual basis
Instrument breakage		Instruments need to be manipulated carefully, especially in a tight joint
Heterotopic ossification	Surgical trauma to the gluteal muscles and bone debris triggers formation of the new bone	Postoperative NSAID administration Wash out of the joint at the end of procedure
Traction injuries		
Femoral nerve Sciatic nerve	Extremes of flexion/extension combined with traction	Limiting duration of traction to 2 hr, and traction force to $<$ 50 lb. Usually resolves within 4 hrs after surgery
Compression injuries		
Pudendal nerve	Force exerted by perineal post used for countertraction	Perineal post $\geq$ 9 cm positioned against the medial thigh Limit traction force $<$ 50 lb
Scrotal necrosis Labia majora hematoma/necrosis	Force exerted by perineal post used for countertraction	Use of muscle relaxants for traction phase of procedure Performing arthrocentesis early on to neutralize the resting negative intra-articular pressure
Vaginal tear		Adequate padding of perineal post and boot Inspection of the scrotum/labia before and after traction application
Portal related injuries		
Lateral femoral cutaneous nerve (LFCN) injury	Suboptimal portal placement	- Neutral rotation of the limb during portal placement - Anterior superior iliac spine and borders of the greater trochanter should always be identified and marked - A lateralized anterior portal is safer; the skin incision should not extend into the subcutaneous fat because of the superficial course of the LFCN

CT = computed tomography; NSAID = nonsteroidal anti-inflammatory drugs

abdominal compartment syndrome has also been described as a result of extravasation of irrigation fluid following arthroscopic removal of a loose foreign body from a hip joint.[52] Importantly, the supine position may be associated with less fluid extravasation than the lateral position, which may be attributable to a gravitational effect of the latter

causing fluid collection in the abdominal and pelvic cavities.[12]

As suggested in the literature, some degree of extravasation of irrigation fluid into periarticular tissues is inevitable and usually benign.[53] While it may not be possible to prevent the extravasation of irrigation fluid during arthroscopy, continuous monitoring and careful assessment of the patient during the procedure is of paramount importance. Keeping the arthroscopy pump pressure at 30 mmHg minimizes fluid extravasation. If the procedure is being performed under general anesthesia, the surgical and anesthesia team should monitor for signs of abdominal distension, edema, and unexpected changes in the patient's vital signs. Additionally, in an awake patient under neuraxial anesthesia, abdominal pain should be sought as a potential indicator of fluid collection. If excessive fluid extravasation is suspected based on the patient's signs and symptoms, the procedure should be stopped, if possible, and an assessment of fluid extravasation via computed tomography or ultrasound should be initiated as soon as possible.[16] A follow-up of the patient's condition should then be carried out with repeat imaging. Treatment options include observation, intravenous furosemide, urinary catheter placement, and potentially even laparotomy.[53]

Hypothermia

Perioperative hypothermia is a well-known complication following surgery and contributes to delayed wound healing, increased rates of infection, and increased blood loss.[54] Hip arthroscopy often requires prolonged operating times and large volumes of irrigation fluid, which further predisposes patients to hypothermia. Importantly, hypothermia in hip arthroscopy has been cited as an early sign of fluid extravasation, since the irrigation fluid used for the procedure is not usually warmed.[47] In their observational study (n = 73), Parodi *et al.* report a 2.7% incidence of hypothermia (temperature < 35°C) in patients undergoing hip arthroscopy for the treatment of FAI.[55] In that study, they identified prolonged surgery time, low body mass index, perioperative hypotension, and low temperature of irrigation fluid as factors contributing to the development of hypothermia.[55] In a follow-up study, the authors identified a fourfold reduction in hypothermia when irrigation fluid was warmed to 32°C.[56] The routine use of a forced-air convective warmer has also been reported to help reduce hypothermia.[57] As with any surgery, consistent temperature monitoring is critical in avoiding perioperative hypothermia.

Infection

Infection after hip arthroscopy has not been well studied. At present, one case report describes septic arthritis following hip arthroscopy, and another describes a suture abscess of an arthroscopic portal.[58,59] Guidelines are currently lacking for antibiotic prophylaxis during hip arthroscopy. Nevertheless, given the length of the procedures performed, the extensive tissue dissection that is involved, as well as the potential use of foreign materials, such as implants and sutures, routine prophylaxis with a broad-spectrum antibiotic should be given preoperatively to all patients.[16] In our institution, we administer a single intravenous dose of cefazolin (1 g for adult patients < 70 kg and 2 g for patients ≥ 70 kg) 30 min prior to surgical incision.

Deep vein thrombosis

While the possibility of DVT and pulmonary embolism (PE) with hip arthroscopy was raised as early as 1989,[60] current literature suggests that the actual rates of postoperative DVT and PE are quite low. A review of over 5,500 patients undergoing hip arthroscopy showed no cases of DVT or PE.[16] Nevertheless, there are other case reports of thromboembolic events occurring after hip arthroscopy, both with and without identifiable risk factors. McCarthy and Lee reported one case of DVT following hip arthroscopy in a patient with Factor V Leiden.[61] Alaia *et al.* encountered a case of contralateral DVT after hip arthroscopy in a patient using oral contraceptives.[62] Another case of DVT following hip arthroscopy was described by Souza *et al.*, with no identifiable risk factors attributed to the patient.[63] In their retrospective review of 81 patients undergoing hip arthroscopy, Salvo *et al.* reported three cases of symptomatic postoperative DVT that were confirmed by ultrasound and resolved after treatment.[64] The only case of fatal PE following hip arthroscopy was described in a patient with multiple injuries who underwent exploratory laparotomy and percutaneous fracture fixation before hip arthroscopy.[65] In this case, it is difficult to attribute the pulmonary embolus to a single causative factor. A study from our own institution found that the incidence of DVT was < 4% following elective hip arthroscopy, which further confirms the safety of the procedure with regard to venous thromboembolic events.[66]

While current guidelines are lacking for DVT prophylaxis following hip arthroscopy, early mobilization is recommended for all patients and routinely used in our

institution. In addition, prophylactic administration of unfractionated heparin 5,000 IU subcutaneously should be considered for patients at increased risk for thromboembolic events, such as a personal history of hypercoagulable syndromes and venous thromboembolism.[67] At our institution, patients considered at high risk of venous thromboembolism (i.e., patients with a history of a thromboembolic event, a known genetic prothrombotic disposition, malignancy, or planned extended travel within two weeks of the index surgery) are given rivaroxaban 10 mg daily for two weeks after surgery and no intraoperative heparin is administered.

Conclusions

Hip arthroscopy is a relatively new procedure that is being used more commonly in the treatment of various hip pathologies. While the ideal anesthetic for hip arthroscopy has yet to be determined, optimizing the anesthetic regimen for individual patients begins with the preoperative assessment and extends into the postoperative period. Both general and neuraxial anesthetic techniques are well suited for hip arthroscopy, and currently, there is a lack of literature comparing the benefits and risks of the two techniques in hip arthroscopy. Thus, the decision to proceed with one approach or the other will depend on the particular patient's comorbidities, the nature and length of the planned procedure, patient positioning, and the preferences of the anesthesia provider and the surgeon.

The mainstay of perioperative and postoperative pain management consists of intravenous and oral opioids and multimodal adjunct analgesics such as acetaminophen and NSAIDS. While this regimen is usually sufficient for most patients, those who are at increased risk of experiencing severe pain or pain that is difficult to control with regular analgesic regimens (patients with chronic pain, extensive hip pathology, opioid tolerance) may benefit from various regional anesthesia techniques performed either pre- or postoperatively.

Overall, hip arthroscopy boasts a favourable safety profile with relatively few risks. Positioning-related complications include nerve injuries, which can be reduced with careful padding and repeated assessment of patient positioning during the procedure. Similarly, extravasation of irrigation fluid can be a rare but devastating complication of hip arthroscopy, and vigilant monitoring by the surgical and anesthetic teams is required for early recognition and prompt treatment. Hypothermia during hip arthroscopy can be managed with forced air convective warming blankets, warmed irrigation fluid, and consistent temperature monitoring. Infections and thromboembolic events following hip arthroscopy are rare but documented, and while antibiotic prophylaxis for infections is widely recommended, prophylactic anticoagulation should be considered for high-risk patients on a case-by-case basis.

Conflicts of interest None declared.

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