Can recent chronic pain techniques help with acute perioperative pain?

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Purpose of review
This article discussed how the knowledge and technique of a few chronic pain procedures benefited the perioperative clinicians in their care of patients receiving specific orthopaedic surgical procedures.

Recent findings
Recent emerging interest in hip and knee denervation for chronic pain management secondary to osteoarthritis stimulates publications on the new understanding of hip and knee joint innervation. The improved understanding of the anatomy allows better precision in targeting the articular branches. The procedures for chronic joint pain such as radiofrequency ablation, chemical neurolysis and neuromodulation procedure have recently been applied to the perioperative care in orthopaedic procedures because of the potential long-lasting analgesia, opioid-sparing effect and consequent improvement in physical function and health-related quality of life after surgery.

Summary
Despite the widespread use of regional anaesthesia and multimodal analgesia in the perioperative pain management, more than two-third of the patients reported severe postoperative pain. Therefore, other therapeutic strategies used in chronic pain management such as radiofrequency ablation and neuromodulation have been proposed to optimize acute postsurgical pain. The early experience with those techniques is encouraging, and more studies are required to explore the incorporation of these procedures in the perioperative care.

Keywords
acute perioperative pain, anatomy of joint innervation, chemical neurolysis, neuromodulation, pain management, radiofrequency ablation

INTRODUCTION

Despite the widespread use of peripheral nerve blocks and multimodal analgesia in the perioperative care, approximately 80% of the patients reported postsurgical pain with 88% of those patients describing the severity as moderate to extreme [1]. Acute postsurgical pain (pain within first 72 h in the postoperative period) is consistently found to be an independent risk factor of chronic postsurgical pain (CPSP) [2▪]. The risk of moderate to severe chronic pain after surgery is almost three-fold higher in orthopaedic surgery than in other types of surgical procedure [3]. The prevalence of CPSP is approximately 9% and 20% of patients following total hip arthroplasty (THA) and total knee arthroplasty (TKA), respectively [4]. CPSP has been related to significant disability compromising health-related quality of life, worrisome increase in opioid consumption [5] and further consumption of healthcare resources. To improve the perioperative pain control and postoperative functional outcomes, regional anaesthesia technique is an important component of the multimodal analgesia [6]. Recently, a few interventional procedures commonly used in the chronic pain population such as neuromodulation and radiofrequency ablation (RFA) have gained attention due to its effectiveness, potential long-term pain relief and lack of serious adverse events [7–9]. The objective of this article is to review the chronic pain interventional techniques, specifically on hip and knee procedures, which may be applicable to the perioperative acute pain management.

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KEY POINTS

- Acute postsurgical pain (pain within first 72 h in the postoperative period) is consistently found to be an independent risk factor of chronic postsurgical pain.
- The implementation of chronic pain interventional techniques in the acute postoperative setting can provide long-lasting analgesia and potentially enhance functional outcomes.
- Emerging interest in hip and knee denervation has led to new understanding of the anatomy of joint innervation.
- Percutaneous peripheral nerve stimulation is a technique that can be used as analgesic strategy in the acute perioperative period.

HIP

Hip fracture is an orthopaedic emergency associated with significant morbidity and mortality especially in the elderly [10]. In most cases, an early surgical fixation is the definitive treatment to facilitate functional restoration and reduce mortality and morbidity associated with this condition. The ageing population usually has multiple comorbidities, including cognitive deficit, and this presents a challenge for anaesthesia care professionals in the perioperative setting including pain management.

REGIONAL ANESTHESIA TECHNIQUES FOR HIP FRACTURE

Regional anaesthesia techniques such as femoral nerve block, fascia iliaca block and 3-in-1 femoral nerve block have been widely used in the perioperative pain management in patients with hip fracture (Fig. 1). These techniques provide superior analgesia and improve the functional outcomes in this population when compared with conventional intravenous analgesia [11,12]. The opioid-sparing effect is important, as the elderly population is more prone to side effects related to opioid use such as nausea, vomiting, constipation and cognitive impairment [13]. On the contrary, undertreated pain also increases the risk of delirium in hip fracture patients [14].

The mechanism how the fascia iliaca and femoral 3-in-1 block spread to the femoral nerve, lateral femoral cutaneous nerve (LFCN) and obturator nerve is unclear. One MRI study suggested that 30 ml injectate would ascend as far as L5 level wherein femoral nerve emerges on the lateral side of psoas [15]. This is at this level that the articular branches of femoral nerve start to leave the main trunk and dive deep to the iliacus muscle [16▪▪]. Therefore, the spread of 30 ml of injectate may not consistently cover the articular branches of the femoral nerve. This spread, however, extends laterally to cover the LFCN consistently [15]. The spread does not travel medial enough to involve the obturator nerve [15]. To cover the lumbar plexus and the obturator nerve, researchers showed in a cadaver study that a suprainguinal fascia iliaca block with 40 ml injectate was required, a volume not commonly used clinically [17]. Detailed examination of the LFCN sensory block shows that sensory change commences from the greater trochanter onward on the lateral side, and the surgical incision for most of hip surgeries extend beyond this area [18▪,19]. This explains in part why the ultrasound-guided LFCN block, when performed as a single nerve block, has shown no differences in opioid consumption after hip surgery [20]. These findings suggest that the fascia iliaca block and the 3-in-1 block provide most pain relief for hip analgesia via the blockade of femoral nerve given the volume routinely used in clinical practice (20–30 ml).

NEW UNDERSTANDING OF HIP ANATOMY

Because of the emerging interest in the hip denervation for chronic hip pain secondary to osteoarthritis, detailed anatomic study on the articular branches of hip joint was recently published [16▪▪]. The anterior and superolateral parts of the hip capsule are where most of the nociceptive fibres for transmitting pain are located [21]. The articular branches supplying this area should be the main target for hip analgesia: femoral nerve, obturator nerve and accessory obturator nerve (AON) [16▪▪].

Current understanding is that the AON and femoral nerve play a greater role than previously reported. The femoral nerve provides branches to the hip joint that are given off proximal and distal to the inguinal ligament. Proximal articular branches are more consistent and numerous than distal ones. These proximal branches descend at L4-L5 level on the lateral border of the psoas, travel intramuscularly through the iliacus muscle and are located alongside the pubic rami, deep to the psoas muscle and tendon and between the anteroinferior iliac spine (AIIS) and the iliopubic eminence (IPE). On the other side, the AON, if present, descends as a single branch deep to the medial aspect of the psoas and passes over the IPE before entering the hip joint capsule. The obturator nerve articular branches also share a consistent anatomical landmark, which is the thickening of the inferomedial acetabulum (IMA) that correlates with the radiographic teardrop.

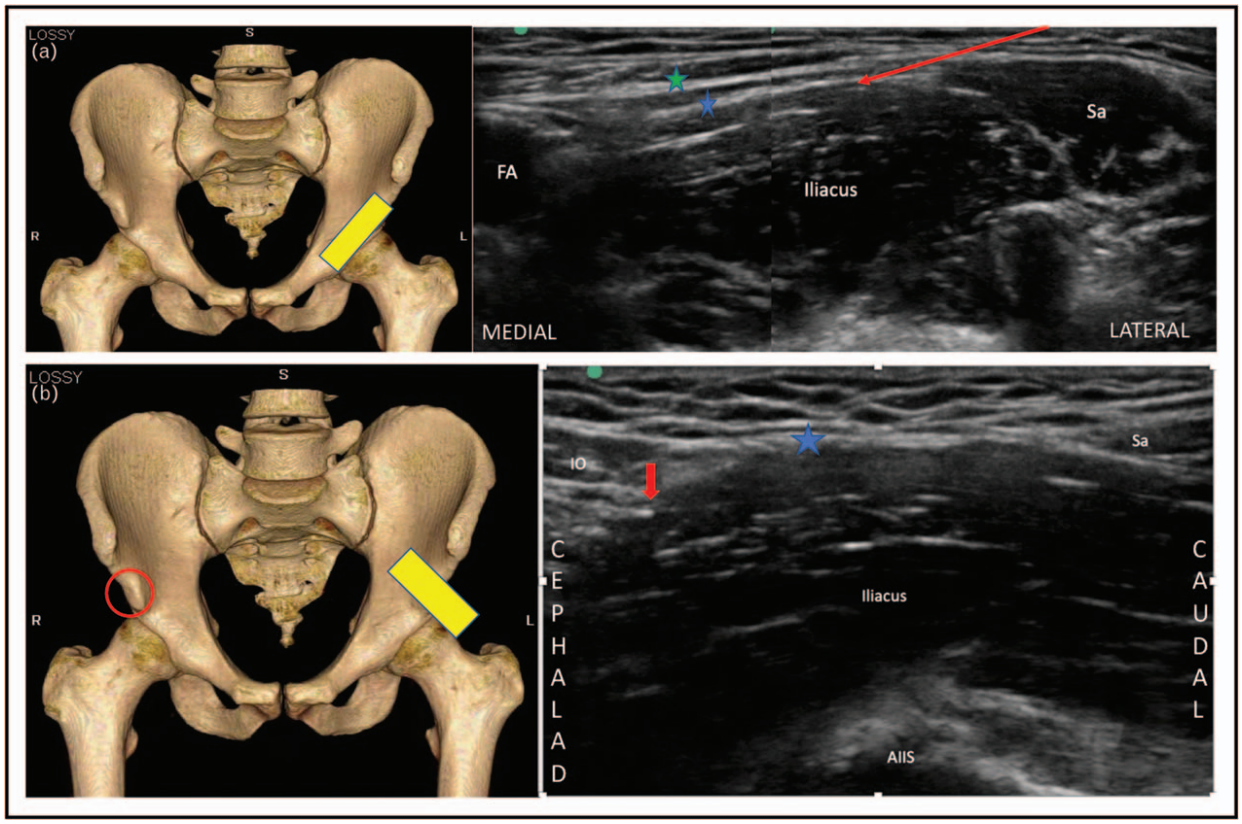

FIGURE 1. (a). Fascia iliaca classical approach: anatomic landmarks. Top left is the skeletal image showing the position of the ultrasound probe (yellow). Top right is the corresponding ultrasound image: FA: femoral artery, Iliacus: iliacus muscle, Sa: sartorius muscle, Green star: fascia lata, blue star: fascia iliaca, Red arrow: needle trajectory for the classical fascia iliaca block in plane from lateral to medial. (b). Suprainguinal fascia Iliaca approach : anatomic landmarks. Lower left is the skeletal image showing the position of the ultrasound probe (yellow). Red circle: anterior inferior iliac spine. Lower right is the corresponding ultrasound image. AIIS: anterior inferior iliac spine, IO: internal oblique muscle, Sa: sartorius muscle, Iliacus: iliacus muscle, Blue star: fascia iliaca, Bold arrow: target for the needle tip. Reprinted with permission from Philip Peng Educational Series.

DEVELOPMENT OF NEW TECHNIQUES FOR HIP ANALGESIA

With a better understanding of the femoral nerve, obturator nerve, AON articular branches for anterior hip and the relevant landmark discernible to the imaging technique, clinicians are able to provide denervation procedure for the management of chronic hip pain. Pain clinicians applied this knowledge in chronic pain practice for procedures such as RFA or chemical neurolysis.

As these anatomical landmarks are also identifiable by ultrasound imaging, a new technique has been developed to target these nerves with the purpose of providing pain relief in hip fracture patients. A brief technical report has been published, describing a new technique called the Pericapsular Nerve Group (PENG) block of the hip [22]. This block involved the injection of 20 ml of local anaesthetic (Bupivacaine 0.25%) in the area beneath the psoas muscle and tendon and above the pubic rami and between AIIS and IPE (Fig. 2). The PENG block was performed in five patients with different hip diseases scheduled for hip surgery resulting in significant static and dynamic pain reduction with a motor sparing effect. The success of this block is related to the pericapsular spread of the injectate in the anterior and medial capsule to cover the articular branches of the femoral nerve, obturator nerve and AON [23].

In a retrospective case series, Ng *et al.* [24] reported 20 patients with inoperable hip fracture due to severe comorbid conditions in whom a chemical hip denervation with 100% alcohol was performed, using the same technique described for the PENG block to target the proximal branches of femoral nerve and AON. In addition, ultrasound landmark was used to locate the articular branches of obturator nerve at the level of the IMA. After the chemical denervation, patients reported a significant reduction in movement related pain at day 1

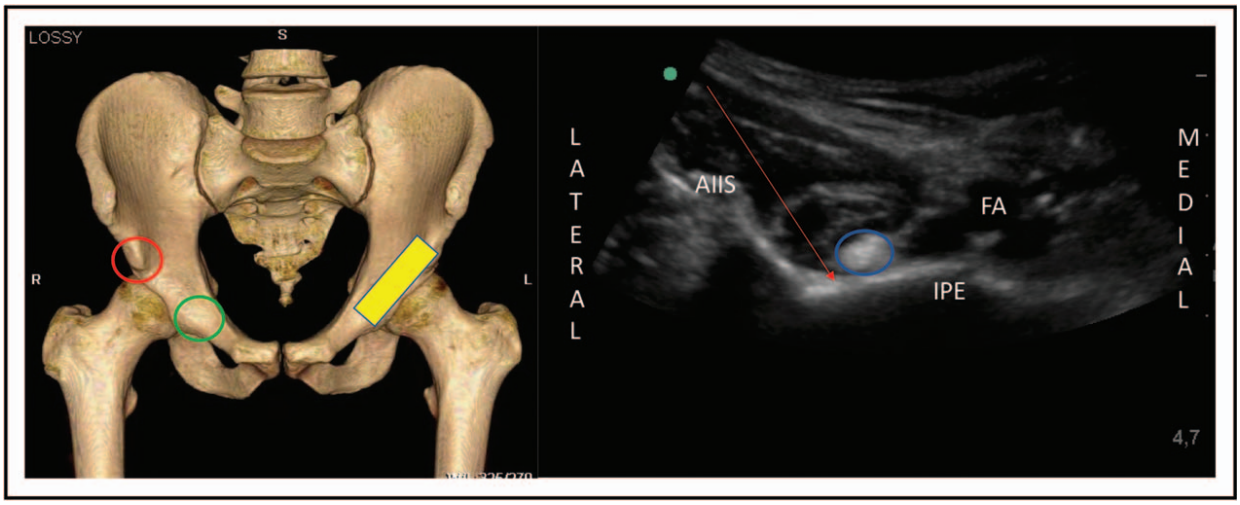

FIGURE 2. Anatomic landmarks for Pericapsular nerve group (PENG) block. Left is the skeletal image showing the position of the ultrasound probe (yellow). Red circle: anterior inferior iliac spine, Green circle: iliopubic eminence. Right figure is the corresponding ultrasound image. AIIS: anterior inferior iliac spine, IPE: iliopubic eminence, FA: femoral artery, Blue circle: psoas tendon, Red arrow: in plane needle trajectory from lateral to medial. Reprinted with permission from Philip Peng Educational Series.

and 5, and 50% of the patients were able to sit out of bed within the first 5 days. Three patients were able to walk with aid by the fourth month. This case series presents a promising alternative for pain control in hip surgery for very ill patients in whom the risks of surgery outweigh its benefits

KNEE

More than 700 000 TKA surgeries were performed in the USA in 2012 and over 67 000 procedures performed in Canada between 2016 and 2017 [25,26]. It was estimated that by 2030, 3.5 million of TKA will be performed per year in US alone [27].

Conventional perioperative analgesia

Perioperative pain management is crucial to provide optimal analgesia and early functional recovery. Recent trials have shown that acute postsurgical pain is an independent risk factor for the development of CPSP following TKA [2▪]. Therefore, effective and longer lasting techniques are preferred for perioperative pain control.

A number of analgesic blocks have been examined for the pain relief after TKA, such as epidural analgesia, single or continuous peripheral nerve blocks with local anaesthesia, and local infiltration analgesia [28]. All these techniques offer superior analgesic benefits over systemic opioids. Because of the use of anticoagulants, peripheral nerve blocks are the preferred regional anaesthesia techniques. Although femoral nerve block was extensively examined, the association of motor weakness leads to the popularity of adductor canal block (Table 1 and Fig. 3) [29–33]. Currently, implementation of image-guided RFA and neuromodulation techniques were examined as potential long-lasting analgesic modalities beyond the early postoperative period.

PREOPERATIVE RADIOFREQUENCY MODALITY

Recently, the articular branches to the anterior knee capsular have been fully characterized (Fig. 4) [34▪]. Effectiveness and safety of RFA techniques in chronic painful knee osteoarthritis has also been studied [35], with eight randomized controlled trials found in the literature [36–43]. In the majority of cases, RFA provided well tolerated and effective long-term therapeutic benefits for pain control, physical function and health-related quality of life. The experience from this literature supports the use of this interventional chronic pain technique to aid with acute perioperative pain.

Investigators have examined the use of preoperative pulse and thermal RFA to the articular branches of the anterior joint capsule several weeks before the patient's surgery. Application of RFA to the articular branches of the knee capsule had been shown to provide moderate pain relief in patients with chronic knee pain secondary to osteoarthritis up to 6 months [44]. With the potential prolonged analgesia benefit, investigators had applied pulsed and thermal RFA 6 weeks before their pending TKA. They demonstrated that such strategy facilitated

Table 1. Comparison of conventional peripheral nerve blocks performed for total knee arthroplasty

Type of peripheral nerve block	Analgesic effects	Impairment of functional mobility
Femoral nerve block	Optimal analgesic effect	Motor block in upper thigh – quadriceps weakness with risk of falling
Adductor canal block	Optimal analgesic effect, similar to femoral nerve block	Preserved quadriceps muscle strength better than femoral nerve block
Continuous ACB	Optimal analgesic effect	Better ambulation and early functional recovery

preoperative rehabilitation programme with improvement of the physical function before the surgery. In addition, this strategy also enhanced the rehabilitation following the knee replacement procedure [44,45].

Neuromodulation techniques

Applying electrical stimulation to alleviate chronic joint pain has been used for years [46]. More recently, this procedure has been performed percutaneously in a wide array of orthopaedic procedures for the management of postoperative pain following TKA, rotator cuff repair, hallux valgus osteotomy and anterior cruciate ligament reconstruction [9,46–50]. The procedure involves the accurate percutaneous placement of the lead adjacent to the peripheral nerves (e.g. femoral and/or sciatic nerves) under ultrasound guidance, confirmation of the recruitment of targeted peripheral nerve with nerve stimulation and connection to an external pulse generator [49,50].

Most of the theories suggest that the analgesic effect of percutaneous peripheral nerve stimulation is related to the 'gate control theory', where electrical current activates large-diameter myelinated afferent peripheral nerve fibres inhibiting transmission of pain signals from small-diameter pain fibres [46].

Despite the limited available data and small sample size, the initial experience of percutaneous neuromodulation for orthopaedic surgery suggested that this a feasible procedure in the immediate perioperative period. In addition, it may provide additional analgesia, decrease in opioid requirements and/or motor-sparing effects [47]. There are

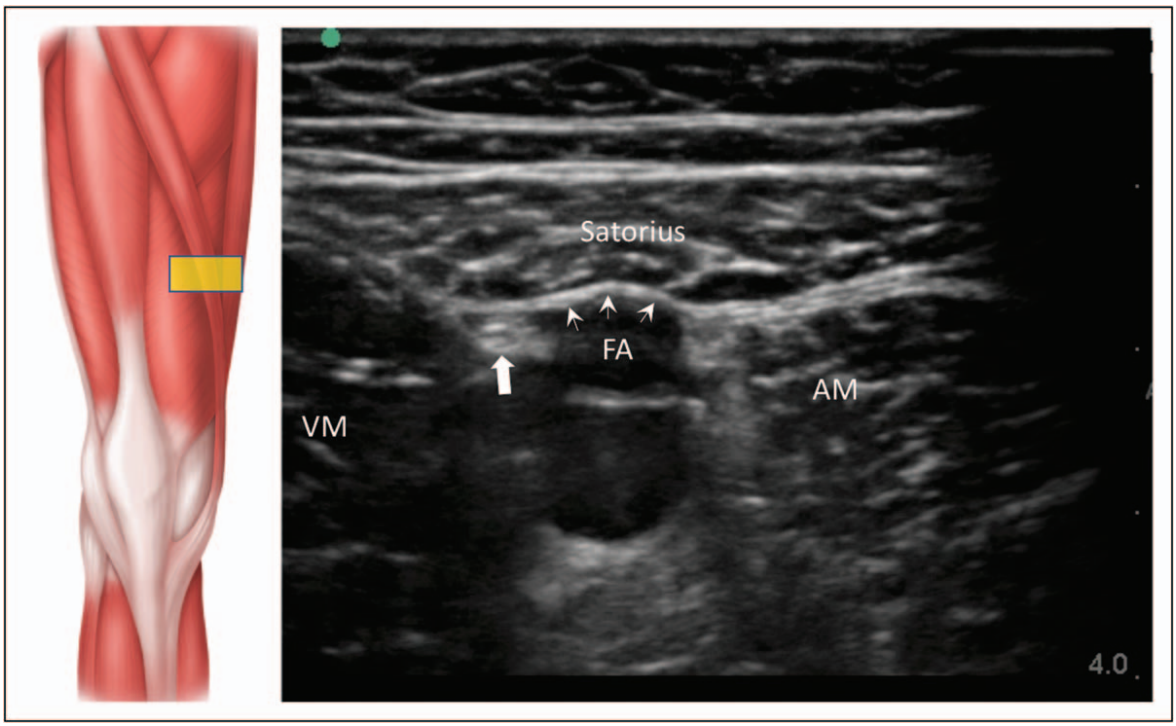

FIGURE 3. Left figure shows the position of the ultrasound probe (yellow) over the proximal end of the adductor canal. The right figure is the corresponding ultrasound image. VM: vastus medialis muscle, AM: adductor muscle, arrows: vastoadductor membrane, FA: femoral artery, Bold arrow: saphenous nerve. Reprinted with permission from Philip Peng Educational Series.

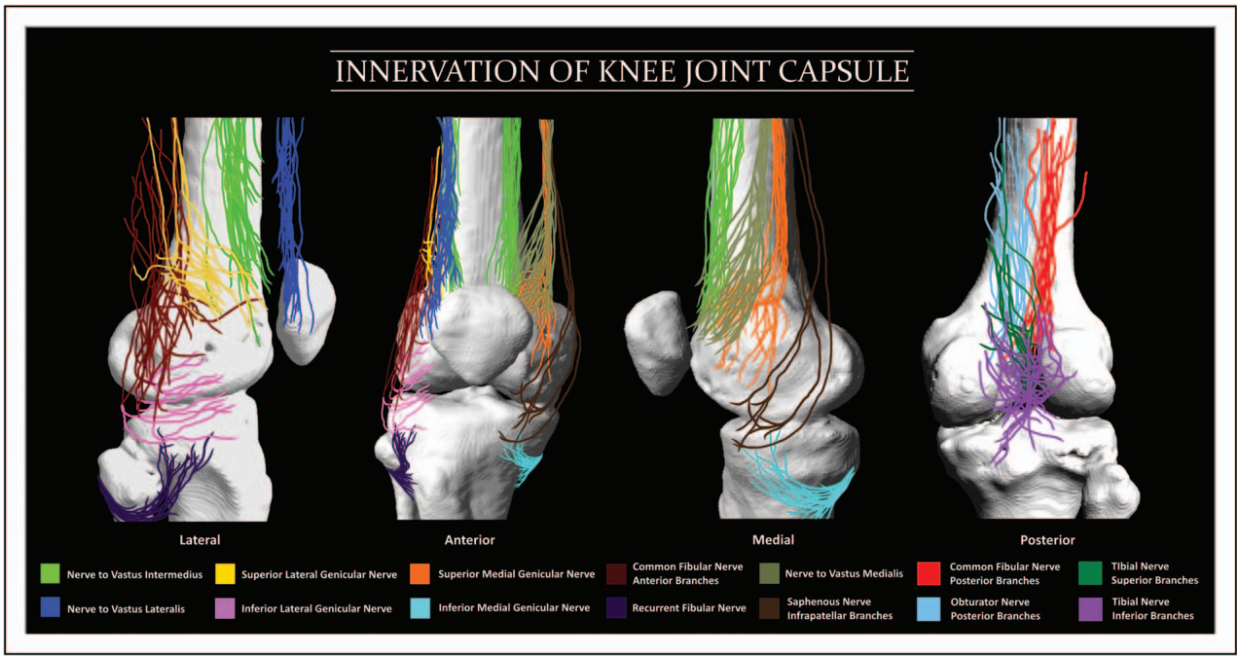

FIGURE 4. The articular branches of knee joint. Reprinted with permission from Philip Peng Educational Series.

still some concerns related to optimal led location, insertion technique, stimulating protocol, among other challenges that need to be addressed in future research [9].

CONCLUSION

The recent literature suggested that the proper use of chronic pain techniques can support and optimize acute pain management. Consequently, patients in the postoperative period might experience long-lasting analgesia, better functional recovery and less consumption of systemic analgesics. The performance of hip denervation using the same technique to target the proximal branches of femoral nerve and AON is a therapeutic strategy that can be used in the perioperative setting. Likewise, RFA of the knee, several weeks before surgical procedure, has facilitated prehabilitation programme and has improved functional outcomes after TKA. On the contrary, the implementation of percutaneous peripheral nerve stimulation for acute pain management is a promising technique that still requires further research. It is essential to understand the latest descriptions of consistent anatomical innervation in order to obtain best analgesic outcomes. Finally, anaesthesia care professionals should receive special training to perform this interventional pain techniques and accomplish best clinical practice to avoid further complications related to unrelieved acute postoperative pain. Further research is required to address the safety and efficacy of these techniques in the acute pain population.

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Conflicts of interest

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