Management of post-operative pain in children and adolescents with scoliosis

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ABSTRACT

Post-operative pain management in children and adolescents undergoing scoliosis surgery remains a major concern. The aim of this study was to review the methods of post-operative pain management in such patients. For this reason, a review of the current literature was performed using the online PUBMED. Inclusion criteria in the review were: prospective, randomized, double-blind studies assessing methods of management of postoperative pain in children and adolescents subjected to spinal surgery due to scoliosis. Twenty-three prospective, randomized, controlled trials were finally included in the review. While intravenous patient-controlled analgesia with morphine remains the gold standard and most widely used analgesia technique for spinal fusion surgery in children and adolescents with scoliosis, other useful methods including epidural analgesia and intrathecal opioids as well as the administration of gabapentin, dexamethasone, acetaminophen and ketorolac seem to have beneficial effects. Taking into consideration the complexity of pain and the high rate of opioid-related adverse events, it is essential to establish a multimodal approach to improve postoperative analgesia.

Key Words: postoperative pain, analgesia, children, adolescents, scoliosis

Introduction

Scoliosis is defined as a three-dimensional structural deformity of the spine and its diagnosis is based on the measurement of the major spinal curvatures involved in the deformity. This measurement is traditionally performed using the Cobb method. An angle greater than 10° defines scoliosis.

There are several types of scoliosis such as idiopathic, functional, neuromuscular and degenerative [1]. Idiopathic adolescent scoliosis is the most common type (80%). It begins in early adolescence, has an incidence of 1-4% and usually affects young girls at the age of 10. Patients who are more skeletally immature are at greater risk of increasing deformities. For patients with a Cobb angle less than 20° careful follow-up is appropriate, while the use of braces is indicated in patients with Cobb angles exceeding 20°. Surgery is reserved for patients with idiopathic adolescent scoliosis who are believed to be at great risk of increasing curvatures during adulthood (Cobb > 40-45°). The primary goals of surgery are to reduce deformity and restore spinal alignment. Spinal fusion aims to prevent long-term

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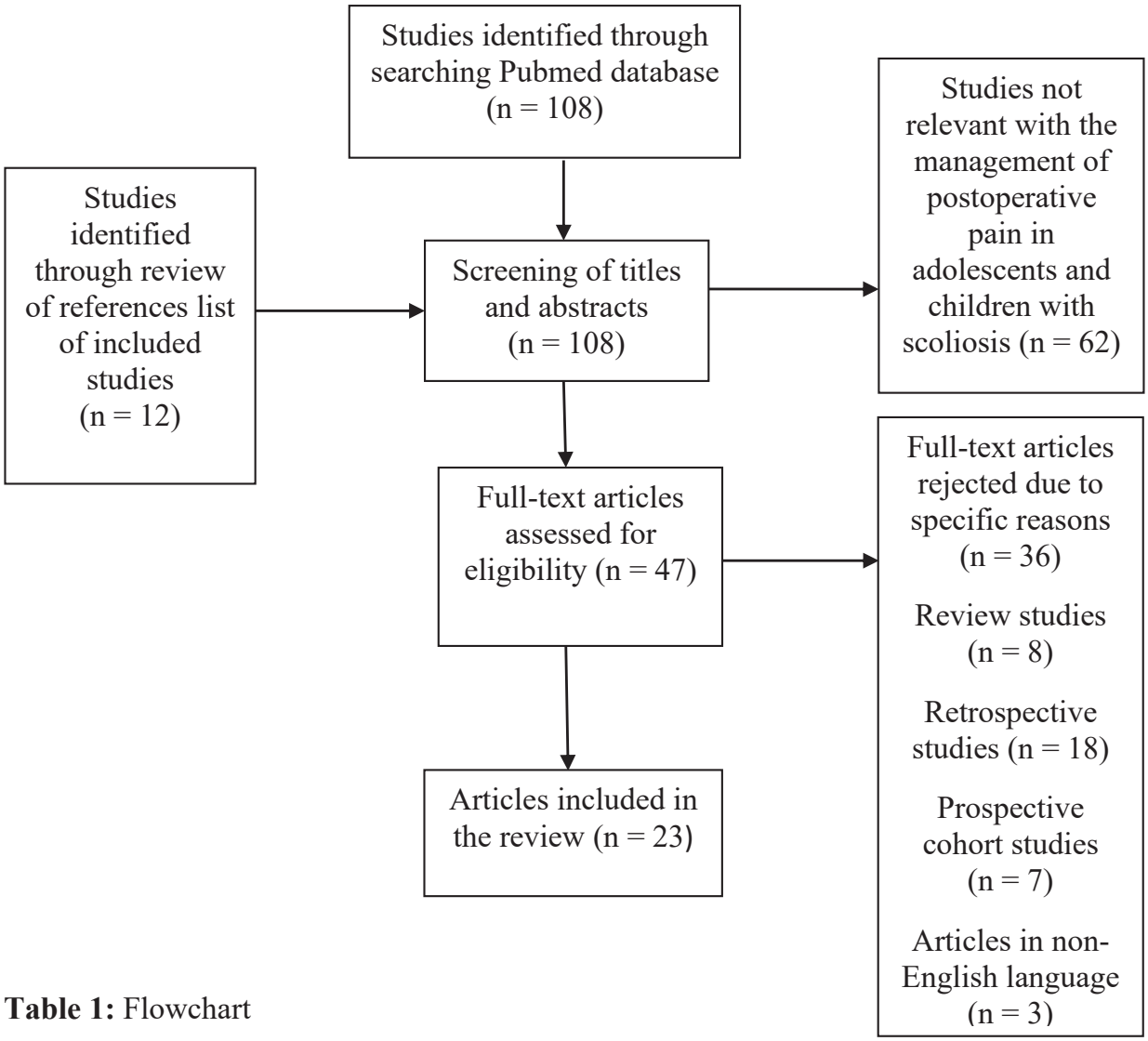

Table 1: Flowchart

consequences of large deformities, which may produce pain and impaired respiratory function [2].

The extensive dissection of bones and soft tissues that takes place during spinal surgery usually results in severe post-operative pain [3], the management of which can be very challenging. Under-treatment of post-operative pain usually reduces patient overall satisfaction and delays post-operative recovery and rehabilitation [4-5]. Intravenous (IV) patient-controlled analgesia (PCA) with opioids is the gold standard of postoperative pain management following spinal fusion. However, opioids have important side effects. Multimodal analgesia after scoliosis surgery has been recently introduced but there are contradictory results or inadequate data regarding its use.

The aim of this study was to review the methods of post-operative pain management in children and adolescents undergoing surgical correction of scoliosis.

Discussion

A review of the current literature was performed using the online PUBMED database and the following keywords: ("treatment" OR "management") AND ("post-operative pain" OR "analgesia") AND ("children" OR "adolescents") AND "scoliosis". Inclusion criteria in the review were: prospective, randomized,

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double-blind studies assessing methods of management of post-operative pain in children and adolescents subjected to spinal surgery due to scoliosis. Retrospective studies, cohort studies, reviews and studies in other-than-English language were excluded. The search resulted in 108 studies. After checking titles and summaries, 62 articles were rejected as irrelevant to the subject. Of the 47 remaining publications, 36 were rejected due to specific reasons. After reviewing the reference lists of the included studies, 12 more studies were included. Finally, there were 23 studies included in the review (Table 1).

Patient-controlled analgesia

PCA enables patients to intermittently regulate the administration of analgesics, mainly opioids, according to pain level. Although IV PCA is mainly used in adults with moderate to severe post-operative pain, it is also considered a safe and effective method of analgesia in children and adolescents [6]. Indeed, IV PCA using morphine is the most widely used method of postoperative analgesia in children and adolescents undergoing posterior spinal fusion for scoliosis [7-8]. The use of morphine is generally considered safe in children [9], as it carries a lower risk of respiratory depression than in adults [10-11].

The main complications of morphine-based IV PCA are nausea, vomiting and pruritus [12]. Several randomized controlled trials have examined the use of morphine in post-operative analgesia in children following spinal surgery for scoliosis [13-19]. Cassady et al, conducted a prospective, randomized study comparing the effectiveness of continuous thoracic epidural analgesia using bupivacaine and fentanyl with that of IV PCA using morphine, in the management of post-operative pain following posterior spinal fusion for idiopathic adolescent scoliosis. No significant differences were observed between groups in post-operative pain scores [13]. Another prospective, randomized study by Gauger et al, compared the effectiveness of patient-controlled epidural analgesia (PCEA) using hydromorphone and bupivacaine with that of IV PCA using hydromorphone, in managing postoperative pain in 38 children and adolescents undergoing posterior spinal fusion for scoliosis. Epidural catheters were found to provide modestly improved analgesia compared to IV PCA ($p \leq 0.042$) [14]. In a randomized prospective trial by Klatt et al, IV PCA, single and dual continuous epidural analgesia were compared in terms of post-operative pain reduction in 66 patients with adolescent idiopathic scoliosis undergoing posterior spinal fusion. The authors concluded that double continuous epidural analgesia with two catheters provided stronger post-operative analgesia compared to single continuous epidural analgesia and IV PCA [15]. Another randomized double-blind, placebo-controlled trial by Munro et al, evaluated the analgesic effect of the combination of IV morphine-based PCA and IV ketorolac in 35 patients after posterior spinal fusion for scoliosis. The intervention group received 0.5 mg/kg of ketorolac along with IV PCA with morphine every 6 hours postoperatively and for 36 hours, while the control group received placebo. The combination of ketorolac and PCA with morphine was associated with reduced postoperative pain scores and opioids consumption [16]. Similarly, another randomized double-blind, placebo-controlled trial by Rusy et al, evaluated the analgesic effect of the combination of IV morphine-based PCA and oral gabapentin in 59 patients following posterior spinal fusion for scoliosis. The intervention group received IV PCA with morphine along with 5 mg/kg of gabapentin 3 times per day for 5 days, while the control group received placebo. The combination of gabapentin and PCA with morphine, was associated with reduced post-operative pain scores and opioids consumption [17]. Weldon et al, in a double-blind, prospective, randomized study, compared the analgesic effect of an intermittent PCA bolus versus PCA plus a continuous infusion (CI), in 44 children and adolescents undergoing elective scoliosis surgery. There were no differences between the PCA and PCA plus CI groups regarding post-operative pain relief and morphine consumption [18]. O' Hara et al, conducted another prospective, double-blinded, randomized study involving 31 patients subjected to elective posterior spinal fusion surgery for adolescent idiopathic scoliosis. Participants were randomized into 3 groups according to the epidural solution infused: Group A received 0.1% of bupivacaine and 5 mg/ml of fentanyl, group B received 0.0625% of bupivacaine and 5 mg/ml of fentanyl and group C received placebo. Intraoperatively, all patients received

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a midthoracic epidural catheter with a set infusion rate followed by IV PCA with morphine postoperatively. The authors concluded that epidural analgesia with bupivacaine and fentanyl had no superior analgesic effect over morphine-based IV PCA [19].

Epidural analgesia

The use of epidural analgesia as an adjuvant to IV PCA for post-operative analgesia in adolescents and children undergoing spinal fusion for scoliosis has been investigated in several randomized controlled trials [13-15,19-22]. Interestingly, the timing of the epidural catheter placement, the numbers and positions of the catheters inserted, the types and doses of drugs administered, and the mode of administration vary widely in the literature. However, the combination of epidural analgesia with IV PCA is more effective in pain reduction in comparison with IV PCA alone, reducing the post-operative quantity of analgesics [12,23]. The success and safety of this method may depend on appropriate techniques used. Reported complications include respiratory depression, neurologic changes, hypotension and over-sedation [24]. In a randomized prospective trial by Blumenthal et al, double continuous epidural analgesia and continuous IV morphine infusion were compared in terms of post-operative pain reduction. Thirty patients with adolescent idiopathic scoliosis were randomized to receive double epidural analgesia with ropivacaine 0.3% or continuous IV morphine infusion. Authors found that double continuous epidural analgesia with two catheters provided stronger post-operative analgesia compared to continuous IV morphine infusion. However, both methods provided efficient post-operative analgesia [20]. Another prospective, randomized, double-blind study by Erdogan et al, compared the effectiveness of patient-controlled intermittent bolus epidural analgesia with that of patient-controlled continuous epidural analgesia, in managing post-operative pain in 47 children and adolescents undergoing posterior spinal fusion for scoliosis. There were no differences in pain scores between the groups. However, post-operative opioid consumption was lower in the patient-controlled intermittent bolus epidural analgesia group [21]. Cohen et al, conducted a prospective, randomized study comparing the effectiveness of extended-release epidural morphine (150 μg/kg) with that of intrathecal administration of morphine (75 μg/kg) in managing postoperative pain in 71 patients undergoing elective scoliosis surgery. No significant differences were observed between groups in post-operative pain scores and total morphine consumption [22].

Intrathecal administration of opioids

As it has been reported in several randomized controlled trials, intrathecal administration of opioids, mainly morphine, after intubation and prior to surgical incision, may reduce post-operative pain and opioid consumption [22,25-27]. However, the duration of this analgesic effect is less than 24 hours. Therefore, this method should be combined with IV PCA. The complications of intrathecal opioid administration are the same as those of IV PCA [28]. In a randomized, prospective trial by Goodarzi et al, intrathecal administration of morphine and sufentanil and IV morphine infusion were compared in terms of post-operative pain reduction, in 80 patients with adolescent idiopathic scoliosis. The authors concluded that intrathecal administration of morphine and sufentanil provided prolonged post-operative analgesia compared to IV morphine administration [27]. The appropriate intrathecal dose of morphine was evaluated in another prospective, randomized trial by Eschertzhuber et al. Forty-six children undergoing scoliosis surgery were randomly allocated to receive 5 μg/kg of morphine plus 1 μg/kg of sufentanil, 15 μg/kg of morphine plus 1 μg/kg of sufentanil intrathecally, or placebo. Both doses of intrathecal morphine succeeded in producing sufficient post-operative analgesia and lower opioids consumption in comparison to placebo [25]. Similarly, Gali et al, evaluated the optimal dose of intrathecal morphine in a prospective, randomized trial. Thirty children undergoing scoliosis surgery were randomly allocated to receive 5 μg/kg of morphine, 2 g/kg of morphine intrathecally, or placebo. Postoperatively, all patients received IV PCA with morphine. The authors concluded that both doses of 2 and 5 μg/kg intrathecal morphine along with IV PCA with morphine, had a stronger analgesic effect in comparison to IV PCA with morphine alone after spinal fusion in children [26].

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Ketamine

Ketamine, an N-methyl-D-aspartate receptor antagonist, is occasionally used to treat neuropathic pain. Four randomized controlled trials have investigated the effects of continuous ketamine infusion in post-operative pain reduction in children and adolescents subjected to spinal surgery due to scoliosis, with controversial results [29-32]. In a prospective, randomized, double-blind, placebo-controlled trial by Perello et al, the analgesic effect of IV administration of ketamine was evaluated in 44 pediatric patients subjected to scoliosis surgery. The intervention group (n=21) received a bolus IV dose of 0.5 mg/kg of ketamine followed by a continuous IV infusion of 2 μg/kg/min for 72 hours postoperatively, while the control group received placebo (n=23). The authors found no statistical difference in post-operative opioids consumption in patients receiving ketamine [31]. Similar were the results of another double-blind, prospective, controlled trial by Pestieau et al. Fifty patients undergoing posterior spinal fusion for scoliosis were randomized to receive peri-operative low-dose ketamine or placebo. The intervention group received a bolus dose of 0.5 mg/kg preoperatively, an intraoperative infusion of 0.25 mg/kg/hr followed by continuous IV infusion of 0.1 mg/kg/hr. The authors found no statistical differences in post-operative pain scores and opioids consumption in patients receiving ketamine [32]. Another prospective, randomized, controlled trial by Engelhardt et al, evaluated the analgesic effect of ketamine in 34 children undergoing scoliosis surgery. Intervention group received a bolus dose of 0.5 mg/kg of ketamine followed by a continuous infusion of 4 mg/kg/min, while placebo group received an equal volume of saline. Post-operative morphine consumption and pain scores did not differ significantly between groups [29]. Minoshima et al, conducted a prospective, randomized, controlled study assessing the effectiveness of combined intra-operative and post-operative administration of ketamine in managing the post-operative pain in 36 patients undergoing posterior scoliosis surgery. The intervention group had intra-operative and post-operative administration of ketamine at a rate of 2 μg/kg/min until 48 hours post-operatively. The control group received equal volumes of saline. The authors observed that post-operative opioids consumption was lower in the ketamine group. Pain scores were similar in both intervention and control groups [30].

Gabapentin - Pregabalin

Anticonvulsant agents, such as gabapentin, have been widely used for the management of chronic neuropathic pain. In scoliosis surgery, two randomized controlled trials have evaluated the analgesic effect of gabapentin in postoperative pain, with contradictory results [17,33]. In a prospective, randomized, double-blind, placebo-controlled trial by Mayell et al, the analgesic effect of IV administration of gabapentin was evaluated in 36 patients subjected to scoliosis surgery. The intervention group (n=18) received a single pre-operative dose of 600 mg of gabapentin, while the control group received placebo (n=18). The authors found no statistical difference in post-operative opioids consumption in patients receiving gabapentin [33]. Another randomized, double-blind, placebo-controlled trial by Rusy et al, evaluated the analgesic effect of the combination of IV morphine-based PCA and oral gabapentin in 59 patients after posterior spinal fusion for scoliosis. The intervention group received IV PCA with morphine along with 5 mg/kg of gabapentin 3 times per day for 5 days, while the control group received placebo. The combination of gabapentin and PCA with morphine was associated with reduced postoperative pain scores and opioids consumption [17]. Recently, gabapentin was reported to have significantly beneficial analgesic effect when administered as a part of a multimodal pain management protocol (ketorolac, acetaminophen, hydromorphone and oxycodone), particularly in the first 48 hours after surgery [34]. In a recent prospective, randomized, placebo-controlled study, the authors found that another anticonvulsant, pregabalin, does not affect post-operative pain scores and opioid consumption after scoliosis surgery in adolescents [35].

Acetaminophen - NSAIDs

Administration of acetaminophen or non-steroidal anti-inflammatory drugs (NSAIDs) decreases post-operative pain and opioid consumption. Two randomized, controlled studies have evaluated the analgesic effect of acetaminophen in patients undergoing spinal fusion

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for scoliosis, showing beneficial effects in post-operative analgesia [12, 36]. In a prospective, randomized, double-blind, placebo-controlled trial by Hiller et al, the analgesic effect of IV administration of acetaminophen was evaluated in 36 patients subjected to scoliosis surgery. The intervention group received IV 30 mg/kg of acetaminophen at the end of surgery and thereafter twice at 8-hour intervals. The authors concluded that acetaminophen provided post-operative pain reduction but did not affect opioids consumption in the first 24 hours [12]. Another prospective, randomized study by Olbrecht et al, recruited 114 patients undergoing spinal fusion for adolescent idiopathic scoliosis. The intervention group (n=44) received IV acetaminophen while the control group received placebo. All patients received IV PCA post-operatively, along with ketorolac and diazepam. The authors found a negative association between IV acetaminophen administration and post-operative opioids consumption [36]. The combination of ketorolac and PCA with morphine, was associated with reduced post-operative visual analogue scale (VAS) scores and opioid consumption, in another randomized, double-blind, placebo-controlled trial by Munro et al, where 35 adolescents were randomly assigned to receive placebo or 0.5 mg/kg of ketorolac along with IV PCA with morphine every 6 hours post-operatively for 36 hours [16]. However, there is a concern about post-operative bleeding and the potentially harmful effects of NSAIDs on bone healing, a vital process for successful spinal fusion [37-38].

Steroids

Steroids have been widely used in adults for the management of postoperative pain. A recent randomized controlled trial has shown that post-operative administration of dexamethasone after posterior spinal fusion was associated with a 40% decrease in post-operative use of opioids, with no increase in wound complications [39].

In conclusion, IV PCA with morphine remains the gold-standard and most widely used method of analgesia in children and adolescents with scoliosis undergoing spinal fusion. Other useful methods include epidural analgesia, intrathecal opioids and administration of gabapentin, dexamethasone, acetaminophen, and ketorolac. Taking into consideration the complexity of pain and the high rate of adverse events associated with opioids, it is essential to establish a multimodal approach to improve post-operative analgesia in children and adolescents subjected to spinal surgery due to scoliosis.

Conflict of interest

The authors declare no conflicts of interest.

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