

REVIEW

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Anesthesia for cesarean delivery: general or regional anesthesia—a systematic review

Mahadi Iddrisu^{1*}  and Zahid Hussain Khan²

Abstract

Background: General anesthesia and regional anesthesia are the anesthetic techniques of choice for cesarean delivery. These anesthetic techniques have their effects on both the fetus and mother. The choice of anesthetic techniques for cesarean delivery depends on several factors including physiological presentation of the patient, experience level of the practitioner, availability of drugs, and equipment, among others. However, whichever technique is used is chosen because of its safety profile and benefit to both mother and fetus. Therefore, this study aimed to compare the effects of general anesthesia against regional anesthesia on fetal and maternal outcomes for cesarean delivery.

Main body: Search methods were conducted on PubMed, Scopus, Embase, and Cochrane library to identify eligible studies using the keywords, MeSH terms, and filters. Two review authors independently assessed the included studies for quality, bias, and accuracy. A total of fourteen (14) studies (1924 women) contributed data for this review. Findings showed that the 1st and 5th minute Apgar scores were higher in regional anesthesia than in general anesthesia while the 1st minute Apgar scores < 7 were more in general anesthesia. On the other hand, fetal umbilical arterial blood pH was lower in regional anesthesia. Also, intraoperative hypotension was more in regional anesthesia while heart rate and estimated blood loss significantly higher in general anesthesia.

Conclusion: In conclusion, regional anesthesia emerges as a better option evidenced by its better fetal and maternal outcomes. However, both regional anesthesia and general anesthesia are still used for cesarean delivery.

Keywords: Regional anesthesia, General anesthesia, Cesarean delivery, Spinal anesthesia

Background

Cesarean delivery can be performed as either elective or as an emergency. Globally, there is an increasing proportion of women giving birth by cesarean delivery in both developed and developing countries which is either done by the woman's request or as a result of complications (Ghaffari et al. 2018). The rate of cesarean delivery in the USA is reported to be around 30% of all live births and 25–30% in Columbia (Páez and Navarro 2012). Also, it has been reported by Little et al. (Little et al. 2016) that the USA has a higher rate of cesarean delivery around 65%. An essential step in the choice of anesthetic

technique for cesarean delivery is the safety and health benefits to the mother and fetus. With the advancement of anesthesia techniques, operations have become safer and secured over the years, but significant maternal and fetal mortality and morbidity (Sumikura et al. 2016) do exist. Anesthesia for cesarean delivery can be achieved either through general anesthesia (GA) or regional anesthesia (RA) such as spinal anesthesia (SA), epidural anesthesia (EA), or combined spinal-epidural anesthesia (CSE).

Regional anesthesia especially spinal anesthesia has been favored as the best choice for elective uncomplicated cesarean delivery due to its avoidance of the airway, less risk of aspiration of gastric content, and easy to perform (Shibli and Russell 2000; Kim et al. 2019). Regional anesthesia is safe and effective, but it does have

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complications such as hypotension, local anesthetic toxicity, post-dural puncture headache (PDPH), and nerve damage (Bakri et al. 2015; Bloom et al. 2005; Afolabi and Lesi 2012; Aregawi et al. 2018). However, general anesthesia is still used especially when regional anesthesia is contraindicated or failed. Advantages of general anesthesia include maintained patent airway, controlled ventilation, and less cardiovascular depression (Devroe et al. 2015). Complications such as failed intubation, failed ventilation, aspiration of gastric content, awareness, pain, and fetal depression (Yehuda Ginosar et al. 2013) are common in GA.

The essence of anesthesia for cesarean delivery is the safe delivery of the fetus and less or no complication to the mother. Therefore, it is important to compare both fetal and maternal outcomes associated with regional anesthesia and general anesthesia.

Several studies have made the attempt to compare fetal outcomes (1st and 5th minute Apgar scores, arterial blood pH) (Kolås et al. 2007; Sabol and Caughey 2016) and maternal outcomes (blood loss, blood pressure and heart rate, analgesia use and requirements) (Kimber Craig 2019). Two studies reported no difference in the 5th minute Apgar score between regional anesthesia and general anesthesia but concluded by stating that no sufficient evidence exists to prove that regional anesthesia stands superior to general anesthesia (Kim et al. 2019; Afolabi and Lesi 2012). However, other studies have reported that regional anesthesia is superior to general anesthesia in terms of fetal Apgar score and umbilical arterial blood pH (Kim et al. 2019; Nguyen-Lu et al. 2016).

Aim of the study

The aim of this systematic review was to compare the effects of general anesthesia with regional anesthesia on fetal and maternal outcomes for cesarean delivery. The fetal outcome variables were 1st and 5th minute Apgar

scores and umbilical arterial blood pH while the maternal outcome variables were blood loss, blood pressure and heart rate, and analgesia requirement.

Main text

Material and method

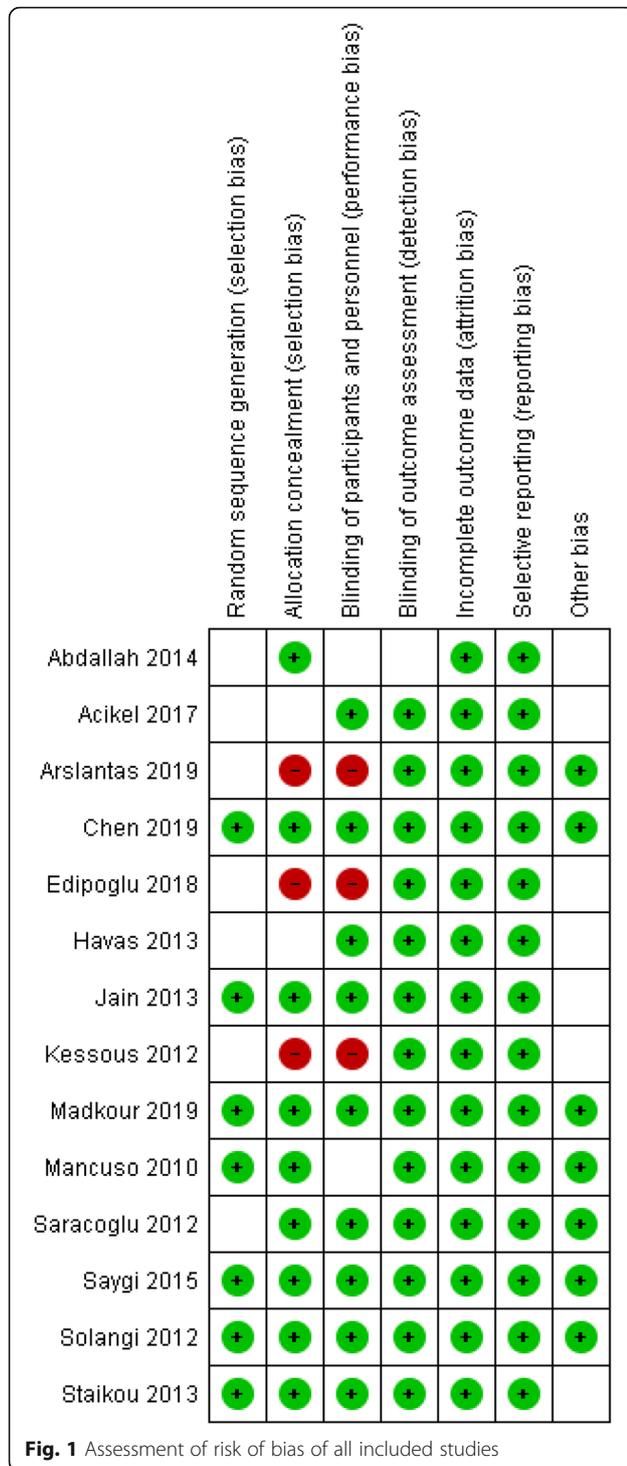
A systematic review study was conducted. A search strategy was used to search on PubMed, Embase, Scopus, and Cochrane using keywords, MeSH terms, and filters as shown in Table 1. Randomized clinical trials and observational studies that compared the effects of general anesthesia and regional anesthesia on maternal and fetal outcomes during cesarean delivery were included. The included studies were reported according to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA). All the included studies were subjectively and independently assessed for risk of biases (Fig. 1) by two authors (MI, ZHK) using the bias domain described in the Cochrane Handbook for Systematic Review of Interventions version 5.3.5 (Higgins et al. 2019). All included studies were assigned a judgment of “high,” “low,” or “unclear” risk of bias across the following domains: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, and selective reporting. Disagreements were resolved by a discussion between the two assessors and a third outside assessor (SWJ), who provided arbitration. Data extraction was independently done by the authors, and discrepancies were resolved through a consensus discussion.

Study selection

The search results and reasons for exclusion from the study are shown in Fig. 2. Initially, we screened a total of 2538 articles from PubMed, Embase, Scopus, and Cochrane. We had 476 duplicated studies removed, and

Table 1 Search strategy

Database	Search strategy	Total number	Date
PubMed	1. “Anesthesia, General” [Mesh]	55,454	6 December 2019
	2. “Anesthesia, Conduction” [Mesh]	63,749	
	3. “Cesarean Section” [Mesh]	44,039	
	4. (“Anesthesia, General” [Mesh] OR “Anesthesia, Conduction” [Mesh]) AND “Cesarean Section” [Mesh]	5046	
	5. (“Anesthesia, General” [Mesh] OR “Anesthesia, Conduction” [Mesh]) AND “Cesarean Section” [Mesh] AND (“2010/01/01” [PDAT]: “2019/12/31” [PDAT])	1464	
Scopus	TITLE-ABS-KEY (“general anesthesia” OR “regional anesthesia” AND “cesarean delivery”) AND PUBYEAR > 2009	547	6 December 2019
Embase	1. (“general anesthesia”:ti, ab, kw OR ‘regional anesthesia’:ti,ab,kw) AND ‘cesarean delivery’:ti,ab,kw AND [2010-2020]/py	406	6 December 2019
Cochrane	1. “general anesthesia” OR “regional anesthesia” AND “cesarean delivery” {Including Limited Related Terms}	128	6 December 2019
	2. limit 1 to yr=“2010 -Current” [Limit not valid in DARE; records were retained]	121	



2003 articles not meeting the inclusion criteria were also excluded. The remaining 59 studies' full text was reviewed, and 45 studies were excluded due to the method and study design used. Finally, 14 randomized controlled trials and observational studies comparing general anesthesia and regional anesthesia were included.

Study characteristics

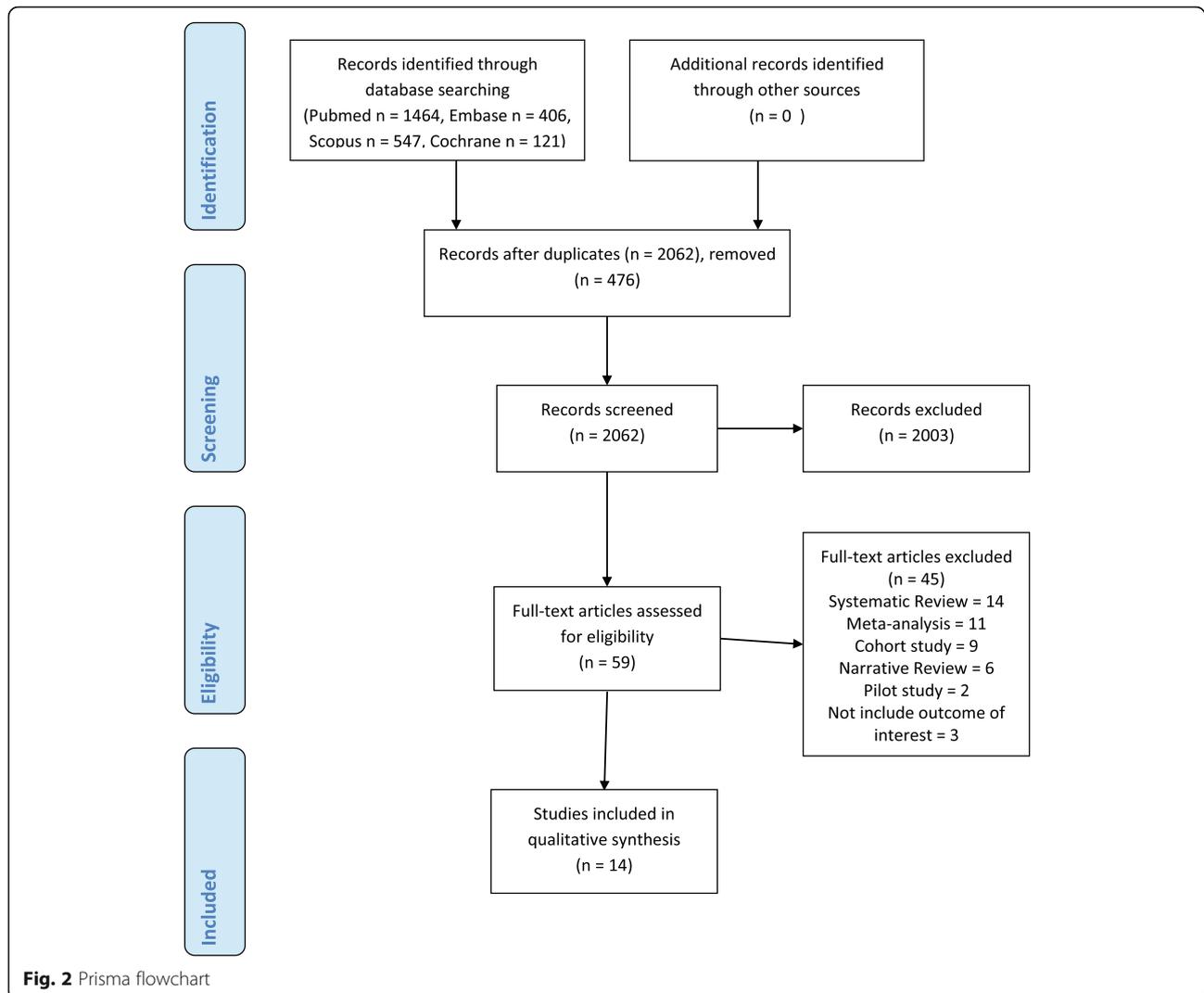
Characteristics of the included studies are detailed in Table 2. Fourteen studies (1924 parturient women) met the inclusion criteria. Nine of the included studies were randomized clinical trials (Jain et al. 2013; Chen et al. 2019; Saygi et al. 2015; Solangi et al. 2012; Mancuso et al. 2010; Staikou et al. 2013; Açikel et al. 2017; Madkour et al. 2019; Saracoglu et al. 2012) and five prospective cross-sectional observational studies (Kessous et al. 2012; Edipoglu et al. 2018; Arslantas and Umuroglu 2019; Abdallah et al. 2014; Havas et al. 2013). Furthermore, ten of the included studies were conducted with parturient women scheduled for elective cesarean delivery (Jain et al. 2013; Saygi et al. 2015; Solangi et al. 2012; Mancuso et al. 2010; Staikou et al. 2013; Madkour et al. 2019; Saracoglu et al. 2012; Kessous et al. 2012; Abdallah et al. 2014; Havas et al. 2013), two studies on emergency cesarean delivery (Açikel et al. 2017; Edipoglu et al. 2018), and the remaining two on both elective and emergency cesarean delivery (Chen et al. 2019; Arslantas and Umuroglu 2019).

Results

The 1st minute fetal Apgar scores between combined spinal-epidural and general anesthesia showed no significant difference (8.98 ± 0.89 , 9.01 ± 0.98 , P value 0.863) (Chen et al. 2019; Abdallah et al. 2014). However, the 1st minute Apgar scores of fetuses born to mothers exposed to spinal anesthesia were higher than those exposed to general anesthesia (7.5 ± 1.7 , 6.3 ± 1.12 , $P < 0.005$) (Saygi et al. 2015; Solangi et al. 2012; Açikel et al. 2017; Madkour et al. 2019; Edipoglu et al. 2018; Abdallah et al. 2014; Havas et al. 2013). This showed that babies who were recorded to have lower fetal Apgar scores were likely to be resuscitated or kept under close monitoring. Again, the number of babies with 1st minute Apgar scores < 7 was higher in general anesthesia, followed by spinal anesthesia which was converted to general anesthesia and spinal anesthesia as the least. Also, the median 5th minute Apgar scores > 7 were higher in spinal anesthesia followed by spinal anesthesia converted to general anesthesia and least in general anesthesia (Madkour et al. 2019).

No difference was found in the 5th minute Apgar scores comparing between regional anesthesia and general anesthesia, but the former had a better score (Chen et al. 2019; Abdallah et al. 2014; Havas et al. 2013). Also, there was no difference between low-dose spinal and general anesthesia with regard to the 1st and 5th minute Apgar scores (Jain et al. 2013).

Regarding fetal umbilical arterial blood pH, only one of our included studies found a significant difference between regional anesthesia and general anesthesia. Umbilical arterial blood pH was lower (acidic) in regional



anesthesia than in general anesthesia ($\text{pH } 7.23 \pm 0.06$ and 7.27 ± 0.04 , respectively) (Jain et al. 2013).

As part of the standard anesthesia protocols, blood pressure and heart rate are always monitored during surgeries. There were no significant changes in the blood pressure and heart rate during the preoperative period (Jain et al. 2013; Chen et al. 2019; Edipoglu et al. 2018; Abdallah et al. 2014). However, intraoperative hypotension was more in regional anesthesia (Jain et al. 2013; Chen et al. 2019; Saygi et al. 2015; Arslantas and Umuroglu 2019; Abdallah et al. 2014; Havas et al. 2013). Also, higher heart rates were recorded in general anesthesia than in regional anesthesia (Jain et al. 2013; Chen et al. 2019; Madkour et al. 2019; Edipoglu et al. 2018). With hypotension recorded in regional anesthesia, more intravenous fluids were used than in general anesthesia (Havas et al. 2013) to prevent or reduce the hypotension. Again, the use of vasopressors like ephedrine (Staikou et al. 2013; Havas et al. 2013) and

phenylephrine (Jain et al. 2013) to treat hypotension was higher (range 0–50 mg against 0–10 mg) in regional anesthesia than in general anesthesia.

Furthermore, there was a higher intraoperative analgesia requirement ($2 \mu\text{g/kg}$ versus $20 \mu\text{g}$ of fentanyl) in general anesthesia (Kessous et al. 2012) while the first postoperative analgesia requirement time was recorded to be longer in regional anesthesia (Saygi et al. 2015; Madkour et al. 2019; Saracoglu et al. 2012; Arslantas and Umuroglu 2019). For instance, the first postoperative analgesia requirement time in regional anesthesia was recorded to be 320 min, against 175 min in general anesthesia. This supports the high quantity of total fentanyl use in general anesthesia than in regional anesthesia (638 mcg fentanyl against 320 mcg fentanyl, respectively) (Saracoglu et al. 2012). Also, blood loss recorded was more (about 400 ml) in general anesthesia (Chen et al. 2019) but did not have any significant effect on the rate of blood transfusion. Return of bowel sounds

Table 2 Study characteristics

Author/year	Title	Method	No. of participants	Location
Abdallah/2014 (Abdallah et al. 2014)	A comparative study of GA versus combined spinal-epidural anesthesia on the fetus in cesarean section	Cross-sectional observational prospective study	60 consecutive pregnant women at term	Kasr Al-Aini Obstetric Hospital, Egypt
Jain/2013 (Jain et al. 2013)	A randomized comparison of the effects of low-dose spinal or GA on umbilical cord blood gases during cesarean delivery of growth-restricted fetuses with impaired Doppler flow	Prospective, randomized clinical trial	40 pregnant women	Tertiary care hospital, India
Arslantas/2019 (Arslantas and Umuroglu 2019)	Comparing the effects of general and spinal anesthesia on the postoperative pain intensity in patients undergoing emergent or elective cesarean section	Prospective, observational study	212 parturient women	Istanbul, Turkey
Chen/2019 (Chen et al. 2019)	Comparison of effects of GA and combined spinal/epidural anesthesia for cesarean delivery on umbilical cord blood gas values: a double-blind, randomized, controlled study	A double-blind, randomized, controlled study	112 parturient women	The First People's Hospital of Jingzhou, China
Saygi/2015 (Saygi et al. 2015)	Comparison of maternal and fetal outcomes among patients undergoing cesarean section under general and spinal anesthesia: a randomized clinical trial	Randomized clinical trial	100 patients who underwent elective cesarean section	Tertiary-level public hospital, Istanbul, Turkey
Solangi/2012 (Solangi et al. 2012)	Comparison of the effects of general versus spinal anesthesia on neonatal outcome	Randomized control trial	160 patients	Peoples Medical College Hospital, Nawabshah, Pakistan
Açikel/2017 (Açikel et al. 2017)	Comparison of patient satisfaction between general and spinal anesthesia in emergency cesarean deliveries	Prospective, single-blind, cross-sectional clinical study	100 patients	Turkey
Edipoglu/2018 (Edipoglu et al. 2018)	Effect of anesthetic technique on neonatal morbidity in emergency cesarean section for fetal distress	Prospective observational study	61 patients	Tertiary Education and Research Hospital, Turkey
Mancuso/2010 (Mancuso et al. 2010)	General versus spinal anesthesia for elective cesarean sections: effects on neonatal short-term outcome. A prospective randomized study	A prospective randomized study	234 pregnant women	Department of Gynecological, Obstetrical Sciences and Reproductive Medicine in Messina University Hospital, Italy
Madkour/2019 (Madkour et al. 2019)	General versus spinal anesthesia during elective cesarean section in term low-risk pregnancy as regards maternal and neonatal outcomes: a prospective, controlled clinical trial	Prospective, controlled clinical trial	64 low-risk pregnant women	Zagazig University Hospital, Egypt
Staikou/2013 (Staikou et al. 2013)	Maternal and umbilical cord oxygen content and acid-base balance in relation to general, epidural or subarachnoid anesthesia for term elective cesarean section	Randomized study	380 parturient women	Athens, Greece
Saracoglu/2012 (Saracoglu et al. 2012)	Neuraxial block versus GA for cesarean section: post-operative pain scores and analgesic requirements	Prospective, double-blinded study	60 patients undergoing elective cesarean surgery	Central Education and Research Hospital, Erzurum, Turkey
Havas/2013 (Havas et al. 2013)	Spinal anesthesia for elective cesarean section is associated with shorter hospital stay compared to GA	Prospective study	188 term parturient women	Istanbul, Turkey
Kessous/2012 (Kessous et al. 2012)	Spinal versus GA in cesarean sections: the effects on postoperative pain perception	Prospective, observational study	153 women were enrolled	Department of Obstetrics and Gynecology at the Soroka University Medical Centre in Be'er Sheva, Israel

and gas discharge took a longer time (9.7 ± 1.3 , 6.8 ± 1.6 h, $P = 0.001$) in general anesthesia (Saygi et al. 2015; Madkour et al. 2019) while the first postoperative urine output was more in regional anesthesia (Madkour et al. 2019).

Also, patients were more satisfied with regional anesthesia (Açikel et al. 2017; Saracoglu et al. 2012) during cesarean delivery and would choose it again if the need arises. Contrary to this, one of our included studies showed that postoperative patient satisfaction was higher in general anesthesia (Chen et al. 2019).

Discussion

Similar to our findings, Dyer et al. (Dyer et al. 2003) in their study showed higher 1st minute Apgar scores in spinal anesthesia than in general anesthesia with the 1st minute Apgar scores < 7 recorded more in general anesthesia. Also, no significant difference in the 1st and 5th minute Apgar scores was found, but higher 1st and 5th minute Apgar scores were recorded in regional anesthesia (Harazim et al. 2019; Shek et al. 2012). It is clearly understood as to why fetal asphyxia, fetal distress, depression, and resuscitation were recorded less in regional anesthesia as the babies were born very active. Caglar et al. (Caglar et al. 2013) in their study did not find much difference in umbilical arterial blood pH, but our findings showed a lower umbilical artery blood pH (acidic) in regional anesthesia than in general anesthesia. This did not have any significant effect on the baby because no cyanosis, body color change, or respiratory distress, although no further investigations were carried out to find the course of low umbilical arterial blood pH.

As part of the maternal outcome, our findings did not show any significant difference in blood loss between regional anesthesia and general anesthesia. Therefore, patients who have regional anesthesia for cesarean delivery are less likely to receive a blood transfusion, unless there is an underlying condition or complications which may either occur before or after the procedure. Aksoy et al. in their study demonstrated that regional anesthesia was associated with less risk of operative blood loss and transfusion. However, in low-risk patients, four patients (2%) under general anesthesia received nine units of blood transfusion (Aksoy et al. 2015).

Khan et al. (Khan et al. 2019) stated that hypotension was common in spinal and epidural anesthesia. Similar to our findings, severe intraoperative hypotension was higher in regional anesthesia. Aregawi et al. (Aregawi et al. 2018) stated that the vasodilation and venous pooling effects of the local anesthetic drugs used for regional anesthesia resulted in severe hypotension. Hypotension was treated with intravenous fluids, phenylephrine (Nguyen-Lu et al. 2016), and ephedrine (Bakri et al. 2015; Dyer et al. 2003). However, Kim et al. (Kim et al. 2019) stated that fetal umbilical arterial blood pH was

adversely affected by the use of ephedrine. This explains why babies whose mothers had received greater ephedrine were found to have low umbilical arterial blood pH (acidic).

Furthermore, the first postoperative analgesia requirement time was longer in regional anesthesia while the postoperative total analgesia consumption was higher in general anesthesia which is in congruent with the other studies (Páez and Navarro 2012; Bakri et al. 2015; Afolabi and Lesi 2012). Patients were more satisfied with regional anesthesia as they could see the surgery being done and hear the cry of the baby (Páez and Navarro 2012; Bakri et al. 2015) while general anesthesia was associated with discomfort, pain, nausea, and vomiting, among others (Tsen and Kodali 2010).

Limitation of the study

Only randomized clinical trials and observational study methods met the inclusion criteria for this study. Again, the search duration was also limited to studies between 2010 and 2019. Therefore, all these were limitations of the study.

Conclusion

In conclusion, both anesthetic techniques are reliable and well-tolerated for cesarean delivery. However, regional anesthesia emerged as a better option for elective cesarean delivery. Regional anesthesia benefits for maternal and fetal outcome are superior to general anesthesia.

Abbreviations

pH: Potential of hydrogen; GA: General anesthesia; RA: Regional anesthesia; SA: Spinal anesthesia; EA: Epidural anesthesia; CSE: Combined spinal-epidural; PDPH: Post-dural puncture headache; PRISMA: Preferred Reporting Items for Systematic Review and Meta-Analysis

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Authors' contributions

MI contributed to the study conception and design, acquisition of the data, analysis, interpretation of the data, and drafting of the manuscript. ZHK contributed to the design of the study, acquisition of the data, reporting of the result, and supervision of the whole process of the manuscript drafting and its critical revision. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets generated during and/or analyzed during the current study are available on a formal request from the corresponding author on reasonable request.

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

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