

Evidence-Based Guideline on Prevention and Management of Shivering After Spinal Anesthesia in Resource-Limited Settings: Review Article

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Background: Perioperative shivering is a common problem faced in anesthesia practice. Unless it is properly managed and prevented, it causes discomfort and devastating problems, especially in patients with cardiorespiratory problems. Surgery, anesthesia, exposure of skin in a cool operating theater, and administration of unwarmed fluids are some of the major causes for the development of shivering among surgical patients. Currently, a variety of non-pharmacological and pharmacological techniques are available to prevent and manage this problem. The available options to prevent and treat shivering include but are not limited to pre-warming the patient for 15 minutes before anesthesia administration, administration of low dose ketamine, dexamethasone, pethidine, clonidine, dexmedetomidine, tramadol, and magnesium sulfate.

Objective: To develop evidence-based recommendations for the prevention and management of shivering after spinal anesthesia in a resource-limited settings.

Methods: The kinds of literature are searched from Google Scholar, PubMed, Cochrane library, and HINARI databases to get access to current and update evidence on the prevention and management of shivering after spinal anesthesia. The keywords for the literature search were (shivering or prevention) AND (shivering or management) AND (anesthesia or shivering).

Conclusion: Pre-warming the patient with cotton, blanket, gown warming, and administering warm IV fluid 15 minutes before spinal anesthesia are possible non-pharmacologic options for the prevention of shivering. Furthermore, pharmacological medications like low dose ketamine, dexamethasone, magnesium sulfate, and tramadol can be used as alternative options for the prevention and management strategies for shivering of different degrees in resource-limited areas.

Keywords: thermoregulation, shivering, perioperative, spinal anesthesia

Background

The autonomic nervous system maintains the core temperature between 36.5 and 37.5 °C by a combination of physiologic and behavioral changes despite the external environmental temperature changes. Administration of anesthesia and surgery are the main cause of temperature dysregulation specifically, the administration of regional anesthesia causes the decline in core temperature with the maximum reduction occurring at 30 minutes.^{1,2}

Shivering is defined as an involuntary trembling of the body that is caused by muscle contraction. It is a physiologic response to increasing the body core temperature in an attempt to raise metabolic heat production and maintain the temperature. However, shivering is associated with different adverse consequences like increased metabolic heat production, increased oxygen consumption, and carbon dioxide production that results in hypoxemia, triggering myocardial ischemia, increased wound pain, delayed wound healing, and interference with monitoring.³

Surgery and administration of anesthesia are the major cause of shivering in a patient undergoing surgery. However, perioperative heat loss, exposure of skin in a cool operating theatre, evaporation from exposed sites, administration of unwarmed fluids, the systematic release of pyrogens, pain, and inhibition of the thermoregulation system by inhibiting tonic vasoconstriction are the main factors that predispose surgical patients to shiver.⁴

Shivering that result due to administration of spinal anesthesia is a frequent event with a reported incidence of up to 50–65%. The mechanism by which spinal anesthesia causes shivering is due to vasodilatation, which facilitates rapid heat loss and causes a redistribution of body heat from the core to peripheral tissue, thus resulting in hypothermia and shivering.^{5,6}

Grading the severity of shivering is vital to allow meaningful comparisons of interventions. Usually, it is graded with a scale described by Bedside Shivering Assessment Score (BSAS) as, grade 0 if there is no shivering, grade 1 if there is no muscle contraction but mild fasciculation of face or neck or peripheral vasoconstriction but no visible shivering, grade 2 if there is a visible muscular activity in only one muscle group, grade 3 if the muscular activity is in more than one muscle group but not generalized and grade 4 if gross muscular activity involving the entire body.^{7,8}

There are non-pharmacological and pharmacological methods available to prevent and treat shivering. Non-pharmacological include giving warm fluid, warm clothes, use of radiant heat, forced air warmers and increasing the operating theater ambient temperature. In addition, it can be managed pharmacologically using, pethidine, tramadol, Clonidine, dexmedetomidine, biogenic amines (serotonin 5-HT₃ receptor antagonist), low dose ketamine, dexamethasone, and magnesium sulfate.⁹ The overall objective of this guideline was to review articles systematically and finally to draw an evidence-based guideline on the prevention and management of shivering after spinal anesthesia. Shivering that occurs after administration of spinal anesthesia causes major discomfort and complication in patients with a history of the cardiorespiratory disease.¹⁰ Currently, there are a variety of pharmacologic and non-pharmacologic prevention and management options. Some of the non-pharmacological interventions that are applied include active cutaneous warming, radiant heat to the body surface, electro-acupuncture, active forced air-warming, electric heating pad, and radiant heating. Apart from the non-pharmacological methods, many drugs have also been used for the prevention and management of shivering which includes but are not limited to pethidine, clonidine, dexmedetomidine, ondansetron, fentanyl, granisetron, and butorphanol.^{11–13} But because of the safety, cost, and unavailability of those interventions in limited-resource settings, it forces us to use an alternative method like pre-warming the patients for 15 minutes, by using a cotton blanket, gown warming, administering warm fluids, low dose ketamine, tramadol, dexamethasone, and magnesium sulfate serves as prevention and management based on the available evidence.¹⁴ As a result, using these alternative medications help us to reduce the unnecessary cost to hospital and patients, and minimize the unwanted side effect of mentioned drugs and it also paves the way for further researches to be done in this regard. Furthermore, as far as our search there is no published guideline on this title, so it can be used as a guide for prevention and management of shivering where resources are constrained. Dexamethasone, and magnesium sulfate serves as prevention and management based on the available evidence.¹⁴ As a result, using these alternative medications help us to reduce the unnecessary cost to hospital and patients, and minimize the unwanted side effect of mentioned drugs and it also paves the way for further researches to be done in this regard. Furthermore, as far as our search there is no published guideline on this title, so it can be used as a guide for prevention and management of shivering where resources are constrained.

Objectives and Aims of the Guideline

The objective of this guideline is to systematically review articles and finally draw evidence-based guidelines on prevention and management of shivering after spinal to improve care provision regarding, prevention and management of shivering after spinal anesthesia for an area with limited resources.

Target Audience and Scope

Target Audience

All groups of health professionals who administer spinal anesthesia including anesthesiologist, anesthetist, and nurse anesthetist.

Target Population

All patients received spinal anesthesia, and combined spinal epidural anesthesia.

Intervention

Non-pharmacological and pharmacological treatment used in prevention and management of shivering after spinal anesthesia.

Inclusion and Exclusion Criteria

All articles which evaluated the prevention and management of shivering among ASA I and II patient who received spinal anesthesia were included. Articles which included patients with thyroid disorder, severe cardiopulmonary disease, and patients requiring blood transfusion were excluded.

Methods and Materials

The review was reported based on preferred reporting items for systematic review and meta-analysis (PRISMA) protocol¹⁵ (Figure 1). Literature was reviewed using a multiple database search including the Cochrane Library, Pub Med, and Google Scholar for all human studies published in English about the prevention and management of post-spinal shivering. From a lot of journals obtained from a search engine, filtering was made based on the intervention, outcome, data on population, and methodological quality. Systematic reviews were appraised and graded according to the AMSTAR-2 appraisal checklist (41). Randomized controlled trials and prospective or retrospective cohort studies were also appraised according to the appraisal checklist of the critical appraisal skill program tool (CASP) (42). After extraction with a patient population and exclusion, eighteen randomized clinical trials, two systematic reviews and meta-analysis study and one prospective cohort study were used for the review using the following keywords: (shivering or prevention) AND (shivering or management) AND

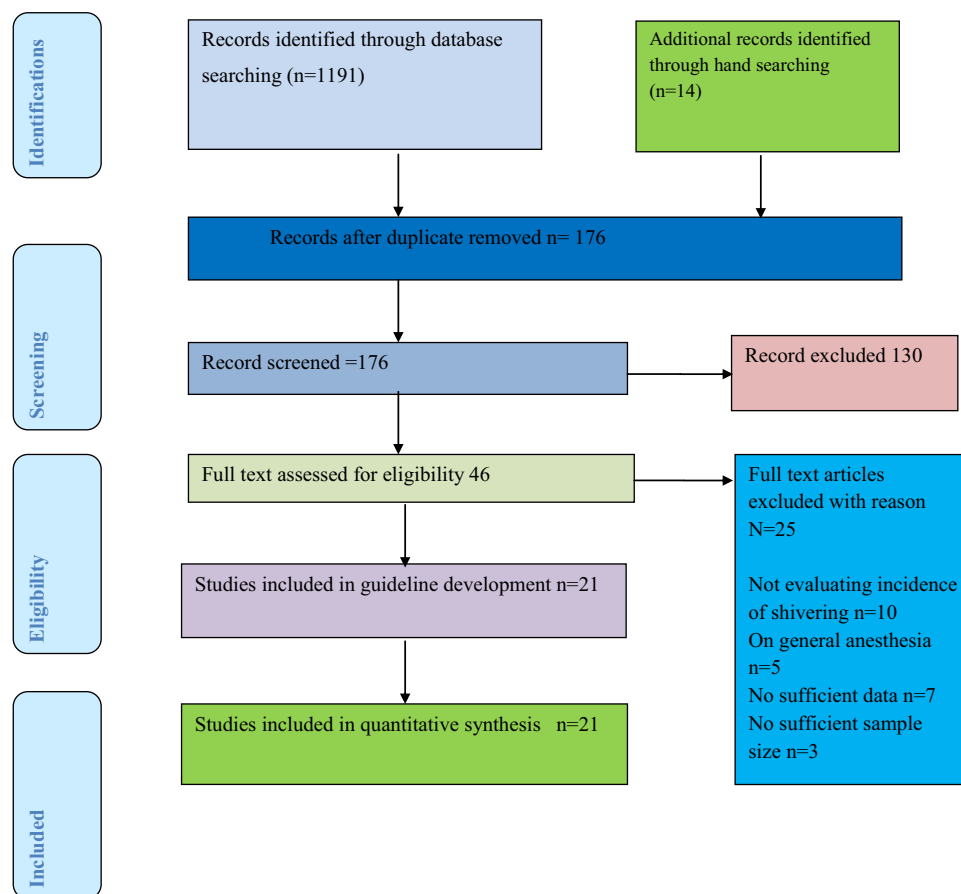


Figure 1 Flow chart selection of studies by PRISMA diagram.

Notes: Adapted from: Liberati A, Altman D, Tetzlaff J et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *Journal of Clinical Epidemiology*. 2009;62(10):e1-e34.¹⁵ Creative Commons Attribution Non-commercial License (<https://creativecommons.org/licenses/by-nc/4.0/legalcode>).

Table 1 Levels of Evidences and Grades of Recommendation

Level of Evidence	Grading Criteria	Grade of Recommendation
1a	Systematic reviews of RCTs including meta-analysis	A
1b	Individual RCT with narrow confidence interval	A
1c	All or none randomized controlled trials	B
2a	Systematic review of cohort study	B
2b	Individual cohort including low quality RCT	B
2c	Outcome research study	C
3a	Systematic review of case control	C
3b	Individual case control study	C
4	Case series, poor quality cohort and case control studies	C
5	Expert opinion without explicit critical appraisal, or based on physiology, bench research or “first principles”	D

Notes: Adapted from Centre for Evidence-Based Medicine. Oxford Centre for Evidence-Based Medicine: Levels of Evidence (March 2009). Oxford: University of Oxford; 2009. Available from: <https://www.cebm.ox.ac.uk/resources/levels-of-evidence/oxford-centre-for-evidence-based-medicine-levels-of-evidence-march-2009>. Accessed August 25, 2022.⁴⁵ © 2022 University of Oxford. CC BY 4.0 license (<https://creativecommons.org/licenses/by/4.0/>).

(anesthesia or shivering) AND (Spinal anesthesia or shivering). The conclusion was made based on the level of evidence that was referred from the WHO for evidence-based medicine (Table 1).

Discussion

Perioperative shivering is a major complication that occurs frequently after neuraxial anesthesia with incidence ranging from 40% to 60% in patients undergoing surgery. It causes devastating discomfort and undesirable outcome, especially in patients with cardiorespiratory problems. Several mechanisms have been developed to describe shivering prevention and management during and after neuraxial anesthesia.^{16,17}

Non-Pharmacologic Options to Prevent and Manage Shivering

Redistribution of heat from the core to peripheral tissue is one of the causes of shivering. Therefore, any mechanisms which block this chain prevent shivering. Pre-warming reduces the distribution of heat from the core-to-peripheral tissue gradient and prevents shivering. It can be accomplished within 15 minutes and could be combined with giving warm fluids, a cotton blanket, and gown warming are effective in preventing a mild form of shivering after anesthesia.

A study done by Horn et al, on 30 healthy pregnant women showed that core temperature after 2 hours of anesthesia was greater in the actively warmed group than in the un-warmed. It concluded that pre-warming reduces maternal shivering and prevents grade 1 shivering and recommends that active warming for 15 minutes in all women undergoing cesarean delivery with a high risk of bleeding, difficulty with wound healing, and cardiac problems and especially in cases of emergency cesarean delivery¹⁸ 1b.

A randomized control trial study in Korea on 45 patients showed that the core temperature at 45 minutes decreased less in patients taking warmed fluid and in patients that were actively warmed than in the control group and the incidence of shivering was significantly less in patients taking warmed fluid and in patients that were actively warmed than controlled group. In conclusion, preoperative forced air-warming and warmed fluid prevents maternal core hypothermia by restoring body temperature above the shivering threshold and reduces maternal shivering in patients during cesarean

section under spinal anesthesia. Finally, they recommend that preoperative fluid warming as it reduces maternal core hypothermia and prevents shivering during cesarean section¹⁹ 1b.

Another RCT study in Japan on 30 parturients also showed that Core temperature (°C) was significantly higher in the warmed fluid group than in the un-warmed fluid group from the time of delivery to the end of surgery. It concluded that administration of pre-warmed intravenous colloid followed by crystalloids masks the central shivering reflex via warmed skin sensory input that helps to prevent grade 1 shivering and maintains the core temperature of the parturient during Cesarean delivery²⁰ 1b.

A study done by Y. Camus et al in France on 18 patients showed that core temperature was $36.7 \pm 2^\circ\text{C}$ in the group receiving warmed fluids and $35.8 \pm 2^\circ\text{C}$ in the control group ($P < 0.05$). Concluded that infusion of warmed fluids, combined with skin-surface warming by increasing the temperature threshold prevents hypothermia and reduces the incidence of postoperative shivering²¹ 1b.

The Role of Ketamine in the Prevention and Management of Shivering

Ketamine is a competitive N- methyl-D- aspartate receptor antagonist that plays a great role in the inhibition of postoperative shivering and it is believed that its anti-shivering action was by non-shivering thermogenesis either by effect on the hypothalamus or by the β -adrenergic effect of norepinephrine.²²

A prospective, RCT study in India on 150 patients showed that a fall in temperature was more significant in the saline and ondansetron group than in the ketamine group at the all-time interval with the Odd ratio of ketamine, ondansetron and saline are 1, 4.33 and 28.33, respectively, which means that shivering in the saline group was 28.83 times higher than ketamine group and 6.65 times higher than in ondansetron. In conclusion, prophylactic administration of low dose ketamine (0.25 mg kg-1) and ondansetron (4mg) produces a significant anti-shivering effect in comparison to placebo in patients undergoing spinal anesthesia without any significant side effects and finally recommended that Ketamine (0.25 mg kg-1) is significantly more effective than ondansetron (4mg) in the prevention of grade 1 shivering¹² 1b.

A study done by D. Dal et al showed that ketamine is as effective as that pethidine in preventing post anesthetic shivering. In addition, ketamine usage offers an advantage over pethidine in preventing respiratory depression, nausea, and vomiting. Finally concluded that ketamine can be alternative prophylaxis against postoperative shivering in patients with bradycardia, hypotension, respiratory depression, nausea, vomiting, and allergic reactions to pethidine²² 1b.

Another RCT study in India showed that giving either ketamine 0.5 mg/kg, clonidine 75 mcg, or tramadol 0.5 mg/kg IV prophylactically just before neuraxial blockade significantly decreased the incidence of grades 1, 2, and 3 of shivering without causing any major side-effects. The incidence of grade 3 shivering showed a statistically significant difference in patients taking pethidine (27/50) as compared with the other groups (group K=5/50, group C=2/50, group T=4/50). It showed that ketamine is more advantageous as it improves the hemodynamic profile by its sympathomimetic effects and it sedates the patient effectively which increases patient comfort during surgery, maintains cardiorespiratory stability, and prevents recall of unpleasant events during the surgery²³ 1b.

Another RCT study in Nepal on 200 patients which compare the use of Tramadol, Ketamine, and ondansetron for post-spinal shivering prevention showed that their usage is effective in preventing post spinal shivering. The odds of normal saline and ondansetron, normal saline and ketamine, normal saline and tramadol were 6.53, 11.76, and 11.76, respectively. It showed that study drugs were effective in preventing shivering and it gives high recommendations for ketamine usage as it stable the patient's hemodynamics in addition to shivering prevention²⁴ 1b.

A systematic review and meta-analysis were done in China which includes 16 articles showed that ketamine reduced the incidence rate of post anesthetic shivering compared to a placebo. It can prevent post-anesthetic shivering without severe side effects and provides clear evidence of the benefit of prophylactic ketamine intervention for preventing post-anesthetic shivering which is helpful in clinical practice²⁵ 1a. Similarly, another prospective RCT in China also showed that prophylactic epidural administration of low-dose ketamine can reduce the incidence and severity of shivering in patients undergoing cesarean section with a combined spinal-epidural²⁶ 1b.

A study was done by Dar AM. et al also found that ketamine was as effective as pethidine in preventing post-anesthetic shivering. In their study, the number of patients shivering at T0 and subsequently at T10 and T20 was significantly less in Group Ketamine and Group Pethidine than in Group Saline However, there was no difference

between Group P and Group K. So in conclusion ketamine was effective as pethidine in preventing anesthetic shivering in addition it also prevents the respiratory depression and hypotension effect associated with pethidine²⁷ 1b.

Dexamethasone Role in Prevention and Management of Shivering

Dexamethasone is a group of steroid medications that has anti-inflammatory and immune suppressant effects. It prevents shivering by regulating immune response and decreasing the temperature gradient between skin and body core via its anti-inflammatory action and inhibition of the release of vasoconstrictors and pyrogenic cytokines²⁸ 1b.

A study done by Destaw B et al showed that Dexamethasone (4 mg) is equally effective as pethidine in the prevention of shivering. According to the study, the incidence and severity of shivering were comparable between the pethidine and dexamethasone groups (p-value >0.05). It also recommends the use of dexamethasone (4 mg) as an alternative to the standard anti-shivering drug as a prophylaxis for the prevention of shivering for patients undergoing TURP procedures under spinal anesthesia²⁹ 2b.

The study done by Entezariasl M et al showed that nineteen cases (47.5%) of the placebo group had postoperative shivering, whereas in the dexamethasone group only four cases (10%) had shivering and the gap between the two groups was remarkable. Also, in patients in the pethidine group, 15 cases (37.5%) had to shiver and the difference between the placebo group was significant. In conclusion, dexamethasone (0.1 mg/kg) in preventing mild to moderate forms of postoperative shivering is better than pethidine, particularly in patients with hemodynamic instability. In addition, it prevents nausea and vomiting that are associated with pethidine³⁰ 1b.

A RCT done by Ibrahim Esmat et al demonstrated that the use of dexamethasone reduces clinically significant shivering in patients undergoing gynecological surgery under spinal anesthesia decreased incidence of 16%.³¹ Another study done by Abd el azeem et al showed that the use of dexamethasone is effective as pethidine in reducing incidence of shivering in patients undergoing TURP surgery under spinal anesthesia. The incidence of shivering was significantly high ($P < 0.05$) in the control group (15 patients, 50%) compared with the dexamethasone group (six patients, 20%) and the pethidine group (seven patients, 23%), with no statistically significant difference between the D and P groups.³²

Another RCT study done in Malaysia showed that administration of dexamethasone is very effective in maintaining body temperature and the reductions of the incidence of shivering in patients undergoing surgery with spinal anesthesia.³³

The Role of Magnesium Sulphate in Prevention and Management of Post-Spinal Shivering

Magnesium sulfate ($MgSO_4$) is an inorganic salt and non-competitive antagonist of N-methyl-D aspartate (NMDA) receptors with a good safety profile and neuroprotective properties under the condition of hypothermia. It plays a big role in suppressing the postoperative shivering through a central effect by reducing the shivering threshold and additionally blocks NMDA receptors, decreasing norepinephrine and 5-HT receptor which both play a role in thermoregulation.³⁴

An RCT study done in Egypt on 120 patients showed that Prophylactic $MgSO_4$ was effective in reducing the incidence of shivering, but when shivering occurred, therapeutic $MgSO_4$ was more effective in the control of shivering as evidenced by the use of rescue Meperidine which was more in Group P (20%) and Group C (50%) compared to none in Group T. This study concluded that prophylactic and therapeutic $MgSO_4$ infusion lowers the incidence of shivering and is used as an effective treatment with minimal side effects finally recommended that 50 mg/kg of IV $MgSO_4$ is effective to treat grade 2 shivering³⁵ 1b.

An RCT study in Egypt on 50 patients scheduled for elective knee arthroscopy showed that intravenous (IV) $MgSO_4$ in a dose of 50 mg/kg was found to be effective for the controlling mild form of shivering without any major side effects. It is also recommended that it could replace Meperidine in middle age patients under spinal anesthesia.⁸ Similarly, Faizshr et al showed that intrathecal injection of 25 mg of $MgSO_4$ improved preoperative shivering in female patients undergoing elective cesarean section³⁶ 1b.

A Systematic Review and Meta-analysis in Korea which include sixty-four trials and 4303 patients have demonstrated that IV administration of magnesium significantly reduces the incidence of shivering in surgical patients. The overall incidence of shivering was 9.9% in the magnesium group and 23.0% in the control group. In particular, the incidence of shivering was lower with IV³⁷ 1a and another RCT study in Egypt on 84 parturient women also showed that 25 mg

MgSO₄ intrathecal is safe and can decrease the incidence and intensity of shivering during cesarean section under spinal anesthesia without having any serious side effects³⁸ 1b.

The Role of Tramadol in Prevention and Management of Shivering

Tramadol is a centrally acting analgesic drug used for the treatment of shivering after spinal anesthesia. It exerts a modulatory effect on central mono-aminergic pathways, inhibiting the neuronal uptake of noradrenaline (pain stimulant) and serotonin in the spinal cord and encourages hydroxytryptamine secretion which affects the body temperature regulation center.

A randomized double-blind cross-sectional study in Iran on 90 patients showed that tramadol was found to be safe and effective in the prevention and treatment of post-spinal anesthesia shivering. In addition, it does not cause any hemodynamic side effects and did not affect arterial oxygen saturation percentage. In the study group, two patients (50%) had moderate shivering and two patients (50%) experienced mild shivering. Neither group experienced severe shivering and between the two groups, a significant difference was seen³⁹ 1b.

An RCT study in India on 60 patients that compare tramadol with pethidine in the prevention of post-spinal shivering showed that onset of the disappearance of shivering was found at 1 minute in the tramadol group (T) and at 3 minutes in pethidine group (P). The complete disappearance of shivering took 5 minutes in the tramadol group while 20 minutes in pethidine group and the recurrence rate of shivering was 10% in T and 50% in P group patients, respectively. It was recommended that tramadol is qualitatively superior to pethidine in treating shivering due to its rapid onset, effective control, less recurrence rate, and minimum side effects in a dose of 1mg/kg when compared to pethidine⁴⁰ 1b.

A study done by Manouchehrian N et al showed that Shivering ceased after 2.57±2.26 and 6.24±4.76 minutes in Tramadol and Meperidine group, respectively, and concluded that tramadol is a more effective agent than Meperidine in the treatment of severe post spinal shivering, with low side effects in obstetric patients⁴¹ 1b.

Another comparative study done in Nepal demonstrated that the use tramadol (0.5 mg/kg) is as effective as meperidine (0.5 mg/kg) for treating post anesthetic shivering with high safety profile.⁴²

The Role of Pethidine in the Treatment of Post-Spinal Shivering

The study done by Zavareh et al showed that pethidine is the most appropriate choice for treatment and preventing postoperative shivering. In comparative studies of ketamine, dexamethasone and pethidine mean value of central temperature in the recovery room was significantly different between the 3 groups. Postoperative shivering was reported in 37.8%, 31.1%, and 11.1% of patients in ketamine, dexamethasone and pethidine groups, respectively. Finally, recommended that pethidine is the most appropriate choice for preventing postoperative shivering⁴³ 1b.

A comparative study done by Ashokkumar Jayaraj et al that assess the effects of intravenously administered meperidine, fentanyl and tramadol in reducing the incidence, onset time and severity of the shivering response in parturients during cesarean delivery under spinal anesthesia demonstrated All study drugs showed significant reduction in incidence, onset time and severity of shivering and greater satisfaction scores compared to the control group ($P < 0.01$). Within each drug class, no significant differences in shivering were found between the high-dose and low-dose groups.⁴⁴

See literatures reviewed for the prevention and management of shivering after spinal anesthesia (Table 2).

Future Directives and Areas of Controversy

Since there is limited evidence regarding the comparison between pharmacologic and non-pharmacologic options for prevention of shivering, the future works should focus on this area:

- Prevention and management of shivering in the geriatric population.
- Prevention and management of shivering in the pediatric population.
- Prevention and management of patients with coexisting problems.

There is a different controversial issue in the prevention and management of shivering like

Table 2 Summary of Some the Literatures Reviewed for Prevention and Management of Post-Spinal Shivering

Author/Year	Study Design	Number of Patients	Intervention	Outcome	Recommendation
B. Shakya et al/ 2010 ¹²	RCT	120	Administration of prophylactic low dose ketamine and ondansetron for prevention of shivering during spinal anesthesia	Low dose of ketamine 0.25 mg/kg decrease shivering without any side effect and no hallucination effect was seen	Recommended and applicable
Rama Wason et al/2012 ²³	RCT	200	Administration of low dose prophylactic ketamine, clonidine and tramadol for the control of shivering under neuraxial anesthesia	Ketamine 0.5mg/kg prevents shivering and It increases blood pressure, heart rate and cardiac output	Recommended and applicable
Same hamdyseyam et al/ April 2020 ⁹	RCT	150	Administration of low dose ketamine vs tramadol in prevention of post-spinal anesthesia shivering	Low dose ketamine decrease the shivering incidence the patient	Recommended and applicable
D. Dal .et al/ April 2005 ²²	RCT	90	Efficacy of prophylactic ketamine in preventing postoperative shivering	Ketamine is effective in prevention of shivering.	Recommended and applicable
Yang Zhou et al / December 2019 ²⁵	A systematic review and meta-analysis	1485	Efficacy and safety of prophylactic use of ketamine for prevention of post anesthetic shivering:	Ketamine reduced the incidence of post anesthetic shivering and maintains hemodynamic of the patients with little sedation	Highly recommendable and directly applicable
Xing Xue et al/ March 7, 2018 ²⁶	RCT	60	Efficacy of prophylactic ketamine for reducing shivering in patients undergoing caesarean section with combined spinal epidural anesthesia	Ketamine reduce incidence of shivering when given with low dose and it increase blood pressure, cardiac output with minimum sedation	Recommended and applicable
Y Camus et al/ August 1996 ²¹	RCT	18	The effects of warming intravenous fluids on intraoperative hypothermia and postoperative shivering	At the end of surgery, core temperature was 36.7M.2°C in the group receiving warmed fluids and 35.8M.2°C in the control group.	Recommended
Destaw B et al 2020 ²⁹	Cohort	64	Efficacy of dexamethasone on prevention of postoperative spinal shivering in comparison with intravenous pethidine	Dexamethasone (4 mg) is equally effective as pethidine (25 mg for prevention shivering after spinal anesthesia	Extrapolated evidence from other studies
MoeenS, et al/ 2017 ³	RCT	90	Intrathecal dexamethasone vs meperidine for prevention of shivering during transurethral prostatectomy	Prevents shivering incidence, intensity and recurrence without any side effect	Recommended
Zavareh, et al/ 2012 ⁴³	RCT	135	The prophylactic effects of ketamine, dexamethasone, and pethidine in preventing postoperative shivering.	Maintains body temperature in addition prevents nausea and vomiting	Recommended

(Continued)

Table 2 (Continued).

Author/Year	Study Design	Number of Patients	Intervention	Outcome	Recommendation
Entezariasl, et al/ 2013 ³⁰	RCT	120	Use of Dexamethasone for prevention of postoperative shivering:	Dexamethasone decrease incidence of shivering in addition it prevents nausea and vomiting	Recommended
M Elsony, et al/ 2013 ⁸	RCT	50	Magnesium sulfate replace meperidine as an anti-shivering agent in spinal anesthesia	Magnesium sulphate decrease shivering plus has sedation score of 2	Strongly recommended
Faiz, et al/2013 ³⁶	RCT	72	IV injection of magnesium sulfate for shivering prevention during cesarean section	IV injection of MgSO ₄ to bupivacaine would improve perioperative shivering	Recommended
Kawakami H, et al/2019 ³⁷	Systematic review and meta-analysis	64 articles	Effectiveness of magnesium in preventing shivering in surgical patients	Mgso4 decrease incidence of postoperative or intraoperative shivering	Highly recommendable
Ibrahim It et al/ 2014 ³⁵	RCT	120	Therapeutic magnesium sulphate for shivering management	Magnesium sulphate prevents shivering and augments analgesic effect of local anesthetic without side effect	Recommended
Manouchehrian et al/2015 ⁴¹	RCT	70	Therapeutic Effect of Tramadol and meperidine for treatment of shivering	Tramadol is a more effective agent than meperidine in the treatment of post spinal shivering	Recommended
Esmat et al/ 2022 ³¹	RCT	300	Prevention of Post spinal Anesthesia Shivering in Gynecological Surgeries: Mirtazapine vs Dexamethasone	Prophylactic administration of mirtazapine or dexamethasone attenuated shivering in patients scheduled for gynecological surgeries under spinal anesthesia	Recommended
El Bakry AA et al/ 2016 ³²	RCT	90	Prophylactic dexamethasone or pethidine for the prevention of postoperative shivering	Prophylactic dexamethasone is as effective as pethidine in reducing the incidence and severity of shivering	Recommended
Chih NY et al/ 2021 ³³	RCT	72	Effect of Prophylactic Intravenous Dexamethasone in Post Spinal Shivering	Dexamethasone can potentially mitigate the reduction in core body temperature with significantly less visible shivering	Recommended
Sulav Acharya/ 2020 ⁴²	RCT	60	Comparison between Tramadol and Meperidine for treating Shivering in Patients undergoing Surgery under Spinal Anaesthesia	Tramadol (0.5 mg/kg) is as effective as meperidine (0.5 mg/kg) for treating post anaesthetic shivering with high safety profile.	Recommended
Jayaraj A et al/ 2019 ⁴⁴	RCT	350	Comparison of meperidine, tramadol and fentanyl for post-spinal shivering prevention during cesarean delivery	Low-dose intravenous tramadol (0.5 mg/kg) allowed shivering prevention and low sedation scores, greater parturient satisfaction and better maternal–newborn bonding.	Recommended

1. The optimal dose of dexamethasone and ketamine for prevention of shivering is still varied among different articles.
2. The optimal temperature level to initiate shivering is still a matter of controversy.
3. There is a controversy on the degree of shivering and its management.

Recommendation

1. We recommend that active warming for 15 minutes combined with infusion of warmed fluids in all patients undergoing surgery under spinal anesthesia to prevent shivering (1b) (A).
2. We recommend prophylactic administration of low dose ketamine (0.25 mg/kg) is significantly effective as pethidine in prevention of shivering (1b) (A).
3. We recommend the use of dexamethasone (4 mg) as an alternative to standard anti-shivering drug as a prophylaxis for prevention of shivering (2b) (B).
4. We recommended that 50 mg/kg of IV MgSO₄ is used effectively to treat grade 2 shivering without any major side effect (1b) (A).
5. We recommend that tramadol is qualitatively superior to pethidine in treating severe form of shivering due to its rapid onset, effective control, less recurrence rate and minimum side effects in a dose of 0.5mg/kg when compared to pethidine (1b) (A).
6. Finally, we recommended that pethidine is the most appropriate choice for preventing severe form postoperative shivering in dosage of 0.5mg/kg and serves as finally rescue drug (1b) (A).

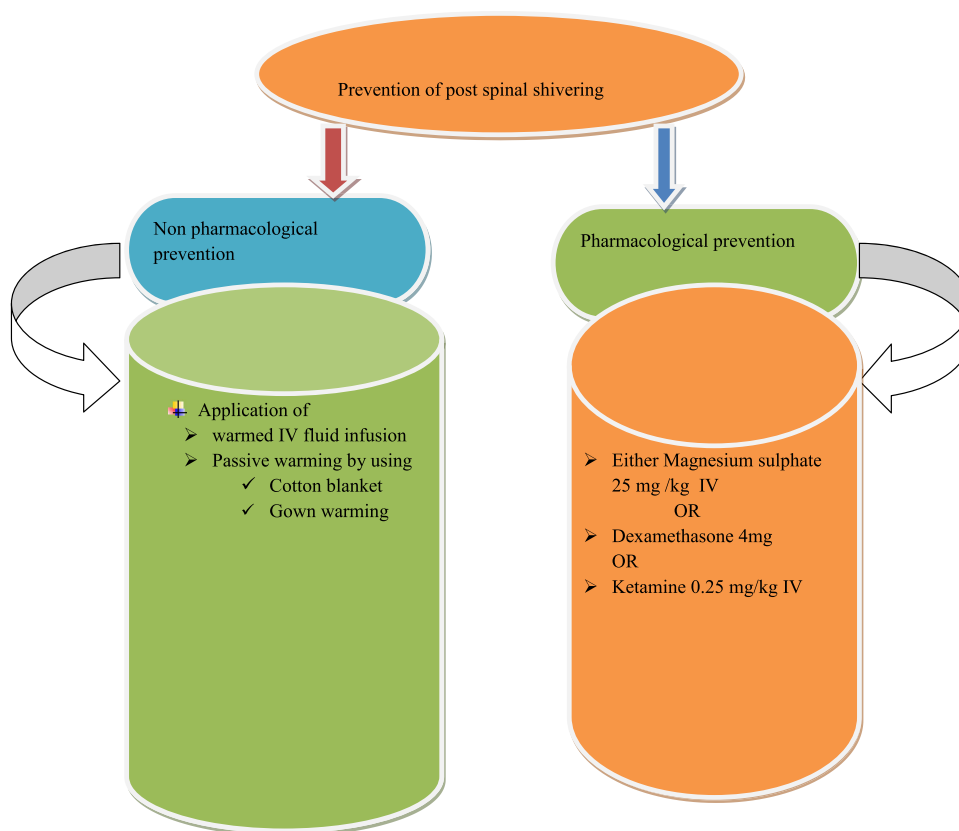


Figure 2 Continue.

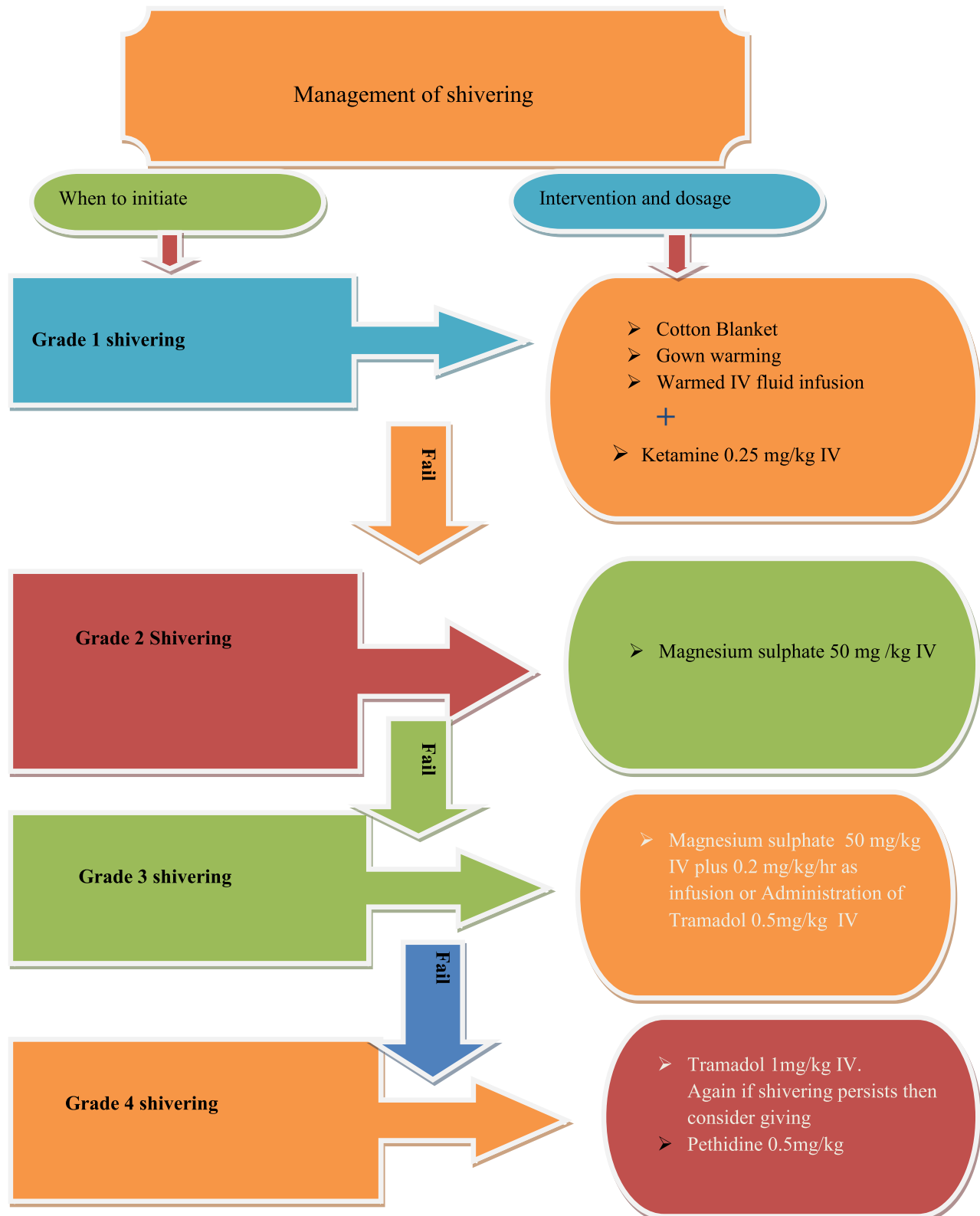


Figure 2 Suggested protocol for prevention and management of shivering.

Summary of the Evidence

Most of the literature recommends variety of non-pharmacological and pharmacological prevention and treatment for shivering after spinal anesthesia. The non-pharmacological management includes but not limited to warmed IV fluid,

gown warming, and cotton blanket for prevention and management of low degree shivering and the pharmacological treatment includes magnesium sulphate 50mg/kg IV, prophylactic low dose of ketamine IV 0.25 mg/kg, dexamethasone IV 0.6 mg /kg for the prevention and management of shivering limited resource setting. As most of the study shows the use of those alternative treatments reduce the side effect of drugs and maximize the comfort to the patients.

Conclusion

Prevention and Management of shivering during surgery is crucial part of the preoperative process as it can reduce risk of many harmful preoperative outcomes. Based on the result of our review, post spinal shivering can be prevented and managed using easily available and economical drugs which are common in limited resource setting. At present, most of the studies recommended that variety of non-pharmacological and pharmacological techniques to prevent and manage this problem. The available option includes but not limited to pre-warming the patient for 15 minute before anesthesia administration, low dose ketamine, dexamethasone, tramadol, and magnesium sulfate. The guideline has been summarized in flow chart form to simplify its application (Figure 2).

Abbreviation

ASA, American Society of Anesthesiologist; MgSo₄, Magnesium Sulphate; NMDA, N-methyl-D-aspartate; RCT, Randomized Controlled Trial; WHO, World Health Organization.

Ethical Approval

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