International Journal of Multiphysics
Volume 18, No. 3, 2024
ISSN: 1750-9548

Shivering during Spinal Anesthesia: A Review Article

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Abstract

Background: Shivering is one of the most commonly recognized complications during spinal anesthesia**.** This shivering leads to patient discomfort, increased oxygen consumption by up to 600%, and potential surgical complications. Effective prevention and treatment of this shivering are essential to ensure patient well-being. **The purpose of this review article** is to through the light on definition of shivering, the incidence of shivering during spinal anesthesia, the onset of shivering, the causes of shivering, the risk factors of shivering, the factors that predispose to perioperative hypothermia, the types of shivering in surgical patients, methods of diagnosis of shivering, grading of shivering, the adverse effects of shivering, preventive and curative measures for shivering in surgical patients. **Conclusions:** Shivering during spinal anesthesia remains a significant concern. It can be prevented and treated by using variety of non-pharmacological and pharmacological measures.

Keywords: Complication of spinal anesthesia**;** Hypothermia**;** Postanaesthetic complications**;** Postoperative shivering**;** Anti-shivering drugs

Definition of shivering

Shivering, as an involuntary oscillatory muscular hyperactivity, occurs in the upper and lower extremities, neck, and jaw for more than 15 seconds, ranging from mild i.e. hair bristling to severe i.e. continuous skeletal muscle contraction **(1,2).**

Incidence of shivering with spinal anesthesia:

The prevalence of shivering varies widely, reported between 5 to 65 percent in general anesthesia and approximately 60 percent in regional anesthesia. Moreover, up to 65 percent of patients experience shivering during the postoperative recovery phase. Thus, it seems that both general anesthesia and regional anesthesia disrupt the body's thermoregulatory mechanisms and compromise the effectiveness of the homeostatic system **(3,4).**

Onset of shivering in surgical cases:

Shivering if occurs usually occurs within 10 minutes after injection of the regional anesthesia. This is the same for spinal, epidural or caudal block but patients undergoing general anesthesia may show muscle shivering during recovery from the anesthesia **(5).**

The causes of shivering during spinal anesthesia in surgical patients:

The exact causes of shivering in surgical patients have not been understood sufficiently **(6).** The most proposed cause of shivering in surgical patients is intra-operative hypothermia. The core body temperature of human beings ranges between 36.5°C and 37.5°C **(7).** The autonomic nervous system maintains this core temperature with behavioral and physiological changes. The core body temperature falls under anesthesia due to the combined effect of direct inhibition of thermoregulation by anesthetics, administration of cold intravenous fluids, decreased body metabolism, and exposure to the cold environment of the operation theatre **(8).** Spinal anesthesia impairs the vasoconstriction below the blocked segments and also causes the redistribution of body

heat from the center to periphery leading to intra-operative core hypothermia **(9).** The thermoregulation is altered as the transfer of temperature-related sensory input from blocked areas to the brain is prevented. A fall in shivering and vasoconstriction threshold has been observed with the spinal block **(10).**

However other causes of shivering in surgical patients have also been proposed as postoperative pain, uninhibited spinal reflexes, decreased sympathetic activity, metabolic alkalosis, suppression of adrenal glands, and cytokine release during surgery contribute to PAS **(11,12).**

Patho-physiology of shivering and non-shivering thermogenesis:

To survive in cold or warm environments, human beings must compensate for heat loss or heat gain via activation or suppression of heat production mechanisms respectively. Also to combat infection, heat production is increased to develop fever. Such cold-defense and febrile responses involve two modes of thermogenesis: shivering thermogenesis and non-shivering (metabolic) thermogenesis **(13).** Heat regulating centre is located in the preoptic area (POA), the most rostral structure in the hypothalamus. This center receives continuous information on environmental temperature from afferent signals coming from cutaneous cool and warm receptors and from central cool and warm thermal receptors coming from internal organs **(13, 14).**

Under cool environments **(Fig. 1, right),** cutaneous cool-sensory signals activate local inhibitory neurons in the median preoptic nucleus, which then reduce the activity of the inhibitory projection neurons in the medial preoptic area which stimulate thermogenic signalling outflows. Under warm environments **(Fig. 1, left),** warm-sensory signals from the skin ascend to the preoptic area and activate inhibitory projection neurons in the medial preoptic area, which tonically inhibit thermogenic signalling outflows **(13).**

In the case of infection, prostaglandin E2 (PGE2), which is produced in response to inflammatory cytokine signals, also inhibits the projection neurons in the medial preoptic area through the prostaglandin E3 (EP3) receptor. The cooling- or PGE2-mediated inhibition of these projection neurons leads to disinhibition of neurons in the dorsomedial hypothalamus, which, in turn, activate somatic and sympathetic premotor neurons in the rostral medullary raphe. The activated premotor neurons finally excite spinal somatic and sympathetic motor outputs, driving shivering and non-shivering thermogenesis, respectively **(Fig. 1) (13).**

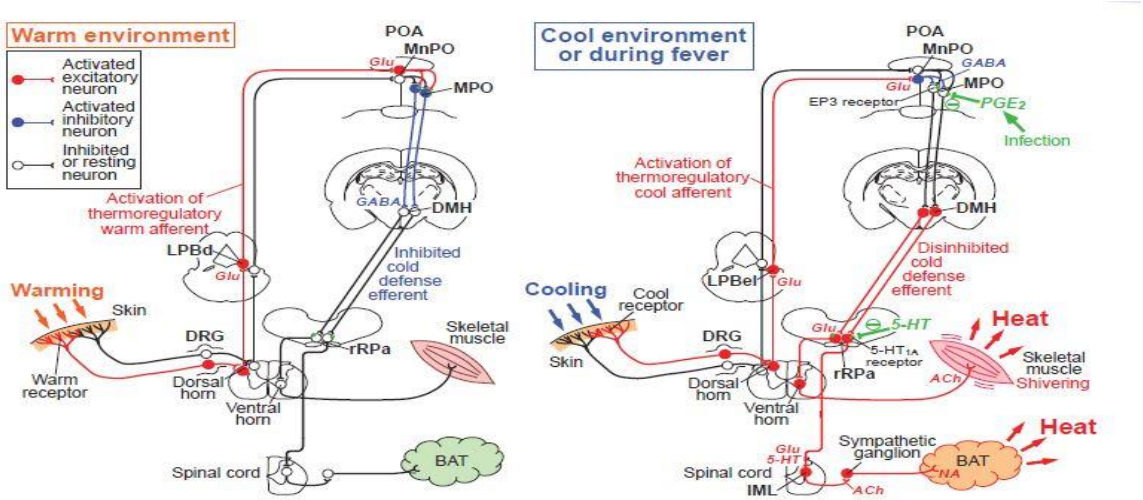

Figure (1): The neuroanatomical and neurotransmitter model for the thermoregulatory network that control body temperature during exposure to either warm or cool environment and during fever. POA= Preoptic area, MnPO= median preoptic nucleus, MPO = medial preoptic nucleus, DMH = Dorsomedial hypothalamus, IML = Intermediolateral nucleus, LBPD = dorsal part of the lateral parabrachial neucleus, rRPa= Rostral raphe pallidus, LPBel=external lateral part of the lateral parabrachial neucleus, DRG = dorsal root ganglion, BAT= Brown adipose tissue, ACh= acetylcholine, NA= Noradrenaline, GABA= Gamma-aminobutyric acid, Glu= Glutamate, 5-HT= 5-hydroxytreptamine, PGE2= Prostaglandin E2 **(13).**

Risk factors of shivering during spinal anesthesia:

- **Age:** Shivering is common in young adults and rare in elders because age impairs thermo-regulatory control **(6). (Eberhart et al., 2005).**

- **Sex:** Shivering is not more common in males than females but is more apparent because the larger muscle mass of males **(15).**

- **Anti-cholinergic premedication** (Atropine and glycopyrrolate): Shivering is more common with these drugs because they lead to peripheral vasodilation with subsequent heat loss prior to induction of anesthesia **(15).**

- **Perioperative hypothermia:** The more serious hypothermia, the higher the probability of shivering **(1).**

Types of shivering in surgical patients:

Shivering in surgical patients is divided into thermoregulatory and non- thermoregulatory in nature **(16).**

1. Thermoregulatory shivering (85% of cases):

Characters:

- Patient is hypothermic.

- Associated with cutaneous vasoconstriction.

- It is of tonic pattern i.e. continuous **(Fig. 2).**

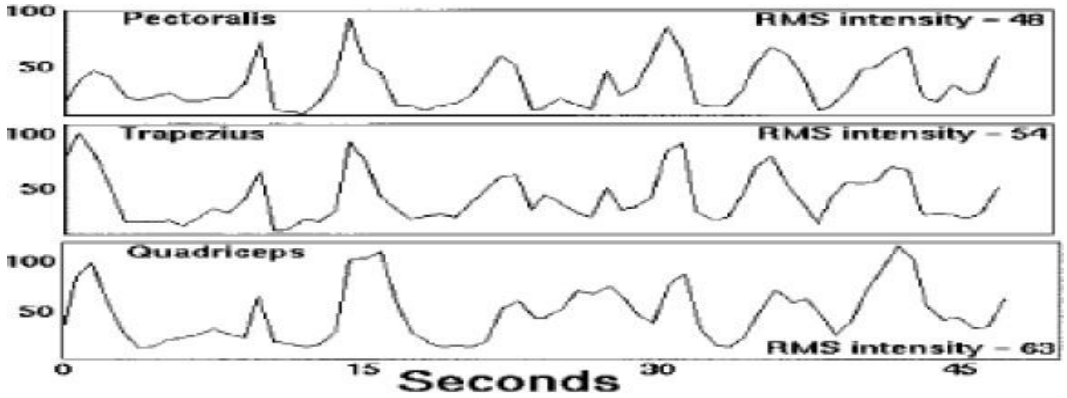

Figure (2): EMG showing a tonic pattern of shivering **(16).**

Mechanism:

- It is a physiological response to central or peripheral hypothermia.

2. Non-thermoregulatory shivering (15% of cases):

Characters:

- Patients are normo-thermic.
- Associated with cutaneous vasodilatation **(17).**
- It is clonic pattern i.e. alternating contractions and relaxations **(Fig. 3).**

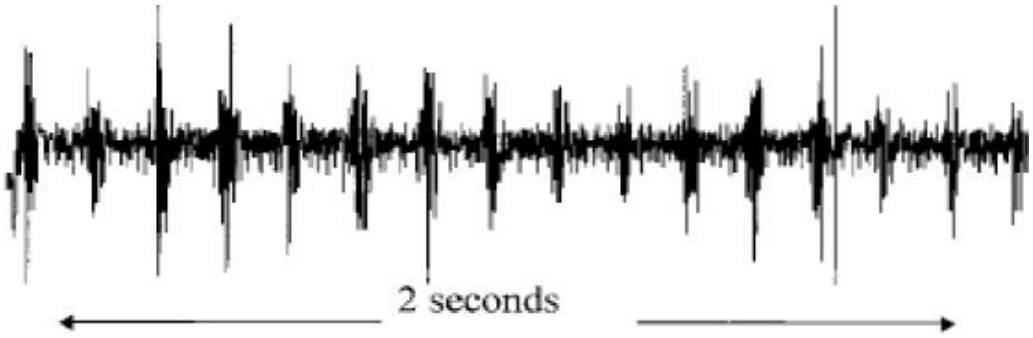

Figure (3): EMG showing a clonic pattern of shivering **(16).**

Mechanism:

It is unknown but may be due to:

- Early recovery of excitatory before inhibitory spinal reflex activity during recovery from general anesthesia.

- Postoperative pain **(18).**

Grading of shivering severity:

There are various scales for grading shivering severity. The commonly used scales are the following:

a. Crowley and Buggy (2008) three-point scale (7):

It is more specific to grade intensity of shivering during neuraxial anesthesia. This three -point scale is as the following:

- Grade 0 = no shivering.

- Grade 1= shivering not interfering with monitoring or causing patient distress.

- Grade 2= shivering interfering with monitoring or causing patient distress.

b. Crossley and Mahajan (1994) five-point scale (19):

This five-point scale is as the following:

- Grade 0= no shivering.

- Grade 1= no visible muscle activity but piloerection, peripheral vasoconstriction, or both are present (other causes excluded).

- Grade 2= muscular activity in only one muscle group;

- Grade 3= moderate muscular activity in more than one muscle group but no generalized shaking.

- Grade 4= violent muscular activity that involves the whole body.

Adverse effects of shivering in surgical patients:

The adverse effects of shivering depend on its severity as the following:

a. In mild shivering (Grade 1-2) the adverse effect is mild rise of O_2 consumption to a level comparable to light exercise.

b. In severe shivering (Grade 3-4) the adverse effect**s** are the following:

i. Dramatic rise of O_2 consumption and CO_2 production up to 600% **(20).**

ii. The dramatic rise of O_2 consumption and CO_2 production is

compensated by increase plasma catecholamines that leads to increase in minute volume and cardiac output

(five folds) to maintain aerobic metabolism, increase in HR and BP and if compensation is failed, this leads to hypoxia, lactic acidosis and vital organs ischaemia **(21).**

iii. Impedance of monitoring of blood pressure, ECG and pulse oximetry **(22).**

iv**.** Patient discomfort and aggravation of postoperative pain by stretching surgical incisions **(16).**

v. Interference of the surgeon's work under spinal and epidural anesthesia (especially during TURP surgery) with subsequent prolongation of the operative time and the possibility of injury to the urethra, bladder and rectum **(23).**

vi. Hindering wound healing by stretching surgical incisions.

vii. Rise of intracranial and intraocular pressure secondary to muscle fasciculation and an increase in CO_2 **(24).**

viii. Disturbing to mothers during labor and delivery and interfering with her ability to hold her baby **(25).**

Prevention and treatment of thermoregulatory shivering in surgical patients during spinal anesthesia:

A. The physical measures for prevention and treatment of thermo-regulatory shivering in surgical patients during spinal anesthesia for are the following:

i. Warming the patient via passive external warming, active external warming**,** and active internal warming **(Tab, 1).**

Passive external warming can be performed by covering the skin with surgical drapes, blankets or plastic bags. A single layer (but not more) of an insulator reduces the heat loss by approximately 30% **(26).**

A*ctive external warming* is be performed by electric heating pad and forced air warming to maintain the core temperature above 36˚C **(27).**

Active internal warming is performed by warming of infused fluids to normal body temperature to avoid heat loss. Warm fluids are probably of benefit only when large amounts are administered for fluid replacement. A liter of fluid at room temperature will reduce the mean body temperature by approximately 0.25˚C. Warming of fluids can be accomplished by using fluid warmers attached to the intravenous tubing **(28).**

Table (1): Methods of avoiding peri-operative hypothermia and their advantages and disadvantages **(29).**

Methods	**Advantages**	**Disadvantages**
Passive external re-warming (e.g. blankets and humidified heated O_2 by mask).	- Non-invasive. - Useful for mild hypothermia in a previously healthy person. - Intense monitoring is not Needed.	- A slow process
Active external re- warming (e.g. forced warmed air, radian heat, and electric/plumbed heat blankets).	- Useful in mild to moderate hypothermia with cardiovascular stability. - Can be combined with passive external re-warming.	- May cause iatrogenic body surface burns. -"Core temperature after drop" may develop.

Active internal re- warming (e.g. heated humidified air, warmed IVfluids, peritoneal dialysis, closed thoracic lavage and extra-corporeal blood warming).	- Most effective modality. - Fastest modality. - Can be used in patients with stable or compromised cardiovascular system.	- Can be invasive. - Patient needs to be intensively monitored.

ii. Warming the operating room via room condition:

The operating room temperature should be greater than 24˚C during induction of anesthesia and while the patient is prepped and draped to avoid heat loss by radiation, convection from skin, and evaporation from surgical wounds when they are large. All patients become hypothermic if the room is below 21˚C **(18).**

iii. Warming local anesthetics (to body temperature) before their administration in case of neuraxial blockade.

B. Pharmacological measures for prevention and treatment of thermoregulatory shivering in surgical patients during spinal anesthesia for are the following:

Indications:

a. In case of failure of physical measures. Or

b. In combination with the physical measures.

Drugs:

There are numerous efficient drugs for prevention and treatment of thermoregulatory shivering in surgical patients during spinal anesthesia (via acting by one or different ways on thermoregulatory shivering). No one of the anti-shivering drugs is ideal. Sometimes more than one drug is needed for control of perioperative shivering. Anesthetist should know the possible side effects of the selected anti-shivering drug and the measures for avoidance and treatment of these side effects **(16).**

The frequently used drugs for prevention and treatment of shivering in surgical patients during spinal anesthesia are meperidine, tramadol, nefopam, clonidine, ketamine, magnesium sulfate, dexamethasone, and midazolam, each with a different mechanism of action **(30,31).**

Meperidine is a synthetic opioid, primarily used for the treatment of moderate-to-severe pain. It can control shivering by affecting kappa receptors or directly affecting the thermoregulatory center **(32).** Although it is effective in treating postoperative shivering at all doses but it has some potential side effects such as respiratory depression and central nervous system depression **(33).**

Tramadol is a strong painkiller from a group of medicines called opiates. It can prevent and treat shivering via inhibiting the reuptake of 5-hydroxytryptamine norepinephrine and dopamine **(34).**

Nefopam is a non-opioid painkiller. It has powerful anti-shivering properties. It is a potent inhibitor of synaptosomal uptake of 5HT, nor-epinephrine and dopamine **(35).**

Clonidine and dexmedetomidine are alpha-2 receptor agonists and reduce shivering by inhibiting norepinephrine reuptake **(36).**

Ketamine is a noncompetitive NMDA receptor antagonist and it has a central sympathomimetic effect by inhibition of postganglionic nor-epinephrine uptake. One of its effects is to decrease core-to-peripheral heat distribution **(37).**

Magnesium sulfate is a drug with central nervous system depressant effect. It has also anti-shivering **(38).**

Dexamethasone is a potent steroid medication. It has anti-inflammatory and immunosuppressant effects. It can reduce the temperature gradient between the core and skin by regulating the immune response and decreasing the release of vasoconstrictors and pyrogenic cytokines so it can significantly decrease the incidence of shivering

during spinal anesthesia **(39)**

Midasolam is a benzodiazepines medication. It has sedative and hypnotic effects. It is effective in prevention and treatment of shivering without causing impairment in thermoregulatory control of the body **(40).**

The issue of choosing the appropriate drug for prevention and treatment of thermo-regularity shivering during spinal anesthesia is still a subject of discussion, as all the available drugs have adverse effects on the patient. Therefore, further research in this area is essential.

Prevention and treatment of non-thermoregulatory type (i.e. shivering with normal body temperature):

- *In case of pain:* providing adequate analgesia.

- *In case of stress:* Providing adequate sedation and reassurance.

Conclusion:

Shivering during spinal anesthesia remains a significant concern. It can be prevented and treated by using variety of non-pharmacological and pharmacological measures.

Funding

There was no funding for this project.

Conflict of interest

Nothing to declare**.**

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