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Postoperative Shivering after Spinal Anesthesia Treated by Lipid Emulsion

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Abstract

Cold exposure in humans significantly increases the oxidation of lipid. Intravenous Lipid Emulsion (Intralipid, Lipofundin, etc.) treatment of shivering after spinal anesthesia is first suggested in the medical literature and successfully used. Intravenous Lipid emulsion is suggested for use in post spinal anesthesia shivering.

Keywords: Shivering; Post Spinal Shivering, lipid emulsion, Intralipid, Lipofundin.

Case Report

A 76 year old woman with normal history, 1.50m height and 42 kg weight who was diagnosed with left lower third ureteral stones, performed retrograde flexible ureteroscopy (URS) under spinal anesthesia.

The patient was admitted into operating room and established intravenous access for 0.9% of NaCl infusion. Constantly monitoring was ensured by ECG, heart rate, pulse oxymetry (SpO_2); non-invasive blood pressure measurements were taken every 2.5 minutes.

Spinal anesthesia (SA) was conveniently performed in lateral position in L2-L3 space inducing with 7 mg marcain spinal 0.5% heavy combined with 0.3mg fentanyl and 0.1 mg morphine. The sensory block level (SBL) reached T6 and the patient could not lift her legs when the surgery started.

Dolacgan 30mg IV was used for shivering after spinal anesthesia 10 minutes. Her heart rate and blood pressure did not vary significantly during 30 minutes of the surgery and she was moved to recovery room. Then, the second dose of 30 mg Dolacgan was administered (IV) again when the patient shivered in her hands after 30 minutes. After that, she remained stable for the next hour, could lift her legs and was discharged to patient's room.

After 3 hours SA, the patient continued to shiver in her right hand only and did not stop with dolacgan. Thus, lipofundin 20% was administered according to LAST protocol. In this case, bolus with 80 ml IV and intravenous infusion 100 ml upon 10 mins, but the symptoms decreased lightly. 30 minutes later, the patient began shivering in her left hand, too. And Lipofundin 20% continued using with 60 drops per min. She stopped shivering 2 hours later with total 400ml lipofundin 20% and remained stable until she discharged from hospital. Video 1 at 16:26pm:

https://www.youtube.com/watch?v=_Vv3eWH3j1A

Video 2 at 16:32pm:

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https://www.youtube.com/watch?v=4QzGuVUowso

Video 3 at 17:20pm:

https://www.youtube.com/watch?v=_2JHR1BYL3E

Video 4 at 19:23pm:

https://www.youtube.com/watch?v=0OUCmnCaXkg

Notice: The patient mentioned in this article has given her signed written permission to use her video clips taken in the recovery room for scientific purposes to all the scientific community all over the world.

Discussion

Shivering, which usually occurs as a thermoregulatory response to cold, may also occur following general or neuraxial anesthesia. Some of the causative factors of this type of shivering may be common to both, but some are particular to neuraxial anesthesia. Although shivering may have beneficial thermoregulatory effects, it places the body under increased physiological stress. In a broad sample of 21 studies, the median incidence of shivering related to neuraxial anesthesia in the control groups was 55%. Both pharmacological and non-pharmacological mechanisms have been found to be effective in reducing this shivering [1].

Shivering is among the common troublesome complications of spinal anesthesia (SA), and causes discomfort and discontentment in parturients undergoing cesarean sections (CSs). The aim of this study was to investigate the effects of intrathecal dexmedetomidine in the prevention of shivering in those who underwent CS under SA.

Fifty parturients planned for elective CSs under SA were enrolled in this prospective, double-blinded, controlled study and randomly divided into two equal groups. Spinal block was achieved with 12.5 mg 0.5% heavy bupivacaine plus 5 μg dexmedetomidine (BD group) or 0.5 mL 0.9% normal saline (BN group). The incidence and intensity of shivering, peripheral and core body temperature, hemodynamic parameters, and adverse events was recorded.

The incidence of shivering was significantly higher in the BN group (52%) than the BD group (24%) (P=0.04). Likewise, the intensity of shivering was significantly higher in the BN group than the BD group (P=0.04). The incidence of adverse events, such as hypotension, nausea/vomiting, and bradycardia, was not significantly different between the two groups, although the grade of sedation was higher in the BD group than the BN group (P=0.004).

We conclude that intrathecal dexmedetomidine is effective in lowering the incidence and intensity of shivering in parturients undergoing CSs under SA without major adverse effects [2].

Shivering associated with spinal anesthesia during Cesarean delivery is an uncomfortable experience for the parturient, which may also cause adverse effects. In this prospective, randomized, double-blind, placebo-controlled study, we sought to evaluate the effect of intrathecal dexmedetomidine, administered as an adjunct to hyperbaric bupivacaine for Cesarean delivery, on the incidence and severity of shivering associated with spinal anesthesia. Patients undergoing Cesarean delivery were randomly allocated to three groups of 30 patients each. Experimental treatments were added to hyperbaric bupivacaine as follows: Patients in group I (control) were administered isotonic saline. Patients in groups II and III received dexmedetomidine (2.5, 5 μg, respectively), mixed with isotonic saline. Shivering was observed in 11, 10 and 2 patients in groups I, II and III, respectively. The incidence of shivering in group III was significantly lower than that in groups I (p=0.005) and II (p=0.01). The severity of shivering was significantly different between the three groups (p=0.01). There were no significant inter-group differences with respect to mean arterial pressure and heart rate at any time point after administration of intrathecal local anesthesia (p>0.05). Intrathecal dexmedetomidine (5 μg) administered as an adjunct to hyperbaric bupivacaine during Cesarean delivery significantly reduced the incidence and intensity of shivering associated with spinal anesthesia [3].

This study was designed to determine the effects of pre-warming on core body temperature (CBT) and hemodynamics from the induction of spinal anesthesia until 30 min postoperatively in surgical patients who undergo total hip replacement under spinal anesthesia. Our goal was to assess postoperative shivering and inflammatory response.

Sixty-two surgical patients were recruited by informed notice. Data for this study were collected at a 1,300-bed university hospital in Incheon, South Korea from January 15 through November 15, 2013. Data on CBT, systemic blood pressure (SBP), and heart rate were measured from arrival in the pre-anesthesia room to 3 hours after the induction of spinal anesthesia. Shivering was measured for 30 minutes post-operatively. C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR) were measured pre-operatively, and 1 and 2 days postoperatively. The 62 patients were randomly allocated to an experimental group (EG), which underwent pre-warming for 30 minutes, or a control group (CG), which did not undergo pre-warming.

Analysis of CBT from induction of spinal anesthesia to 3 hours after induction revealed significant interaction between group and time (F=3.85, p=0.008). In addition, the incidence of shivering in the EG was lower than that in the CG (χ^2=6.15, p=0.013). However, analyses of SBP, heart rate, CRP, and ESR did not reveal significant interaction between time and group.

Pre-warming for 30 minutes is effective in increasing CBT 2 and 3 hours after induction of spinal anesthesia. In addition, pre-warming is effective in decreasing post-operative shivering [4]. The aim of this study is to compare the efficacy of combination of meperidine and dexamethasone with that of placebo, meperidine alone, and the combination of ketamine and midazolam in preventing shivering during spinal anesthesia. This is a prospective, placebo-controlled study.

The setting is at an operating room of a university-based teaching hospital. Two hundred American Society of

Anesthesiologists I and II patients undergoing orthopedic and urologic surgery under spinal anesthesia were included.

Subarachnoid anesthesia was performed by using 15mg of 0.5% hyperbaric bupivacaine. Patients were randomly allocated to receive saline (placebo, group C), meperidine 0.4mg/kg (group Me), ketamine 0.25mg/kg plus midazolam 37.5μg/kg (group KMi), and meperidine 0.2mg/kg plus dexamethasone 0.1mg/kg (group MeD). All drugs were given as an intravenous bolus immediately after intrathecal injection.

During surgery and stay in the recovery room, shivering score, blood pressure, and some other adverse effects were recorded at 5-minute intervals. Axillary and tympanic temperatures were recorded at 15-minute intervals during the perioperative period.

The incidence of shivering after 30 minutes of spinal anesthesia in groups C, Me, KMi, and MeD was 64%, 20%, 20%, and 4%, respectively, which was significantly higher in group C compared with other groups (P<0.0001). Regarding adverse effects, there was no significant difference between groups (P≥0.2). Axillary temperature significantly increased in the 15th-120th-minute interval in groups Me, KMi, and MeD (P<0.0001) and in group MeD was higher than that in other groups. Core temperature decreased in the 15th-120th-minute interval in group MeD, lower than that in other groups (P<0.0001).

Prophylactic use of meperidine 0.2mg/kg plus dexamethasone 0.1mg/kg was more effective than meperidine 0.4mg/kg as a sole agent or the combination of ketamine 0.25mg/kg and midazolam 37.5μg/kg in preventing shivering resulting from spinal anesthesia [5].

We investigated the efficacy and safety of ondansetron during cesarean section under spinal anesthesia. We sought randomized controlled trials (RCTs) on ondansetron during spinal anesthesia for cesarean section in The Cochrane Library, PubMed, MEDLINE, and Web of Science from their inception to September 2016. Altogether, 21 RCTs were included in this study. Meta-analysis showed that the ondansetron group had a lower incidence of nausea/vomiting and bradycardia than the placebo group during cesarean section under spinal anesthesia [relative risk (RR) = 0.43, 95% confidence interval (CI) (0.36, 0.51) and RR = 0.45, 95% CI (0.26, 0.80), respectively]. There were no significant differences in the incidences of pruritus, hypotension, or shivering during cesarean section under spinal anesthesia [RR = 0.92, 95% CI (0.83, 1.02); RR = 0.72 (0.50, 1.06), 95% CI (0.50, 1.06); and RR = 0.89, 95% CI (0.71, 1.11), respectively]. Ondansetron effectively reduces the incidences of nausea/vomiting and bradycardia under spinal anesthesia during cesarean section [6].

The optimum dose of dexmedetomidine for shivering control with the least hemodynamic derangements is still under research. We compared the efficacy, hemodynamic and side effects of dexmedetomidine in 3 different doses with those of meperidine for the treatment of shivering in patients undergoing spinal anesthesia for minor elective lower abdominal surgery in a prospective double-blind randomized clinically controlled study in a University hospital.

One hundred twenty patients developed shivering under spinal anesthesia. On shivering, patients were randomly allocated to receive an intravenous 2 mL bolus dose of meperidine 0.4 mg/kg (meperidine group, n=30), dexmedetomidine 0.5 μg/kg (DEX I group, n=30), 0.3 μg/kg (DEX II group, n=30), or 0.2 μg/kg (DEX III group, n=30). Control of shivering, time taken for cessation of shivering, response rate, recurrence, hemodynamic changes, sedation score, tympanic temperature, and side effects were noted and compared between groups.

The groups were comparable regarding demographic profile, tympanic temperature decline, and shivering onset time (P>0.05). Lower shivering cessation time (P<0.001) and higher response rate (P<0.01) were observed in DEX I and II groups compared with DEX III and meperidine groups, with a non-significant difference between DEX I and II groups. Recurrence of shivering activity was higher in DEX III group (36.7%, P<0.01) compared with DEX I (10%), DEX II (6.7%) and meperidine (16.7%) groups. Lower heart rates, systolic and diastolic blood pressure mean values were recorded in DEX I group (P<0.05). Nine patients (30%) in DEX I group were in levels 3-5 of sedation (P<0.02) compared with 5 (16.66%), 2 (6.66%), and 4 (13.3) patients in DEX II, DEX III, and meperidine groups, respectively. This study is limited by its small sample size.

Among the 3 doses investigated, dexmedetomidine 0.3μg/kg effectively treated shivering associated with spinal anesthesia with modest hemodynamic and sedation effects [7].

Shivering is among the unpleasant and potentially harmful side effects of spinal anesthesia. The aim of this randomized double-blind clinical trial was to compare the antishivering effect of two different doses of intrathecal pethidine on the incidence and intensity of shivering and other side effects in patients who underwent cesarean section.

In this study, 150 parturient females scheduled for nonemergent cesarean section were randomly allocated to three groups. Spinal anesthesia was performed with 0.5% hyperbaric bupivacaine (12.5 mg), plus 0.5 mL of 0.9% saline in the standard group (S group), and the same dose of bupivacaine with 5 mg (P5 group) or 10 mg of pethidine (P10 group). Demographic and surgical data, incidence and intensity of shivering (primary outcome), hemodynamic indices, forehead and core temperatures, maximum sensory level, Apgar scores, and adverse events were evaluated by a blinded observer.

There were no significant differences between the three study groups regarding the demographic and surgical data, hemodynamic indices, core temperatures, and maximum sensory level (P>0.05). The incidence and intensity of shivering were significantly less in the P5 and P10 groups (P<0.001) when compared with the S group. There were no significant differences between groups for secondary outcomes, except pruritus, which was more common in the P5 and P10 groups when compared with the S group (P=0.01).

Low dose of intrathecal pethidine is safe, and can decrease the incidence and intensity of shivering during cesarean section, without having major side effects [8]. We compared the effects of dexmedetomidine (Dex) and fentanyl as adjuvants to local anesthetics in spinal anesthesia. Two researchers independently searched the PUBMED, EMBASE, Cochrane library, and CBM for randomized controlled trials comparing the effects of Dex and fentanyl as adjuvants to local anesthetics for intrathecal injection.

A total of 639 patients from nine studies were included in this meta-analysis. The results showed that Dex resulted in statistically significant longer duration of stable sensory block (mean difference [MD]=27.12; 95% confidence interval [CI] [9.89, 44.34], P<0.01, I2=97%), sensory block (standardized mean difference [SMD] =3.81; 95% CI [2.35, 5.27], P<0.01, I2=97%), motor block (SMD =3.64; 95% CI [2.19, 5.08], P<0.01, I2=97%), and pain free period (SMD =2.98; 95% CI [1.69, 4.27], P<0.01, I2=96%); reducing the incidence of pruritus (relative risk [RR] =0.15; 95% CI [0.06, 0.39], P<0.01, I2=0%) compared with fentanyl. However, the onset of sensory and motor block, the time to peak sensory level, and the incidence of hypotension and bradycardia, and the side effects (nausea, vomiting, shivering and respiratory depression) were not significantly different between Dex and fentanyl.

Compared to fentanyl, Dex as local anesthetics adjuvant in spinal anesthesia prolonged the duration of spinal anesthesia, improved postoperative analgesia, reduced the incidence of pruritus, and did not increase the incidence of hypotension and bradycardia [9].

We sought to investigate the effect of morphine and fentanyl on shivering when used adjunctively with bupivacaine during spinal anesthesia in patients undergoing varicose vein surgery on an outpatient basis. The study included a total of 90 patients, aged 25-45 years, ASA I-II, scheduled to undergo endovenous laser ablation under spinal anesthesia for lower extremity venous insufficiency/ varicose vein disease. Patients were randomly allocated into 3 groups: Group M (morphine group) received 5 mg 0.5% hyperbaric bupivacaine +0.1 mg morphine, Group F (fentanyl group) received 5 mg 0.5% hyperbaric bupivacaine +25 μg fentanyl, and Group C (control group) received 5 mg 0.5% hyperbaric bupivacaine + physiologic saline. The level of sensory blockade was assessed with pin-prick test and the level of motor blockade was assessed with Bromage scale at 5-min intervals. Shivering grade and time to first postoperative analgesic requirement was recorded. Level and time of sensory block showed a slight but insignificant increase in the Morphine Group and Fentanyl Group. Time of postoperative analgesic requirement was significantly longer in patients who received morphine (p<0.05). Shivering was significantly less common in patients who received morphine and fentanyl than in patients who are in the Control Group (p<0.02). Morphine or fentanyl may be used as adjunctives to spinal anesthesia to prevent shivering in patients undergoing venous surgery [10].

The aim of this study was to compare fentanyl and butorphanol for the relief of postoperative shivering in spinal anesthesia. A total of 100 American Society of Anesthesiologists physical status Class I and II patients aged 19-60 years belonging to both sexes who were posted for elective surgical procedures under spinal anesthesia were divided into two groups (fentanyl and butorphanol) and monitored intraoperatively for the occurrence of shivering and time taken to control shivering after administration of fentanyl and butorphanol drugs.

Relief of shivering is rapid and more effective with fentanyl than butorphanol. There is a significant increase in pulse rate, mean arterial pressure, respiratory rate (RR), and decreased in oxygen saturation at the onset of shivering and also a decrease in core body temperature. Sedation, nausea, vomiting, and recurrence of shivering are more with butorphanol with fentanyl.

On the basis of the study, it is concluded that fentanyl is more effective and takes less time to control perioperative shivering as compared to butorphanol [11]. Shivering is a common post anesthesia adverse event with multiple etiologies. At present tramadol is a widely used drug for the control of shivering. However, tramadol may cause a lot of nausea and vomiting. Hence, the need to find a better drug with less of side effects. The aim of this study was to compare the efficacy of dexmedetomidine and tramadol in the treatment of post-spinal anesthesia (SA) shivering as well as to compare their side-effect profile.

This prospective, double-blind, randomized controlled trial was conducted in a tertiary care hospital. A total of 100 patients having shivering after SA were enrolled, out of which fifty received dexmedetomidine (Group A) and 50 received tramadol (Group B). The response rate, time to cessation of shivering and side effects (if any) was noted. All the results were analyzed using Student's t-test and Chi-square test.

All patients who received dexmedetomidine as well as tramadol had cessation of shivering. The time to cessation of shivering was significantly less with dexmedetomidine (174.12±14.366 s) than with tramadol (277.06±23.374 s) (P<0.001). The recurrence rate of shivering with dexmedetomidine was less (6%) as compared to tramadol (16%). Nausea and vomiting was found to be higher in the case of tramadol. On the other hand, dexmedetomidine caused moderate sedation (modified Ramsay sedation score = 3-4) from which the patient could be easily awoken up.

Dexmedetomidine offers better results than tramadol with fewer side effects [12]. Shivering after spinal anesthesia is a common complication and can occur in as many as 40%-70% of patients after regional anesthesia. This shivering, apart from its physiological and hemodynamic effects, has been described as even worse than surgical pain. The aim of the study was to evaluate and compare the effectiveness of prophylactic use of intravenous (IV) ketamine, dexmedetomidine, and tramadol for prevention of shivering after spinal anesthesia.

Two hundred American Society of Anesthesiologists physical status I and II patients subjected to spinal anesthesia were included in the study. The subjects were randomly divided into four groups to receive either ketamine 0.5 mg/

kg IV or tramadol 0.5 mg/kg IV or dexmedetomidine 0.5 microgm/kg IV or 10 mL of 0.9% normal saline (NS). All the drugs/NS were administered as IV infusion over 10 min immediately before giving spinal anesthesia. Temperature (core and surface), heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure, peripheral oxygen saturation were assessed before giving the intrathecal injection and thereafter at 5 min intervals. Important side effects related to study drugs were also noted.

Shivering after spinal anesthesia was comparatively better controlled in group receiving dexmedetomidine as compared to other groups (P=0.022). However, the use of dexmedetomidine was associated with significant hypotension which responded to single dose of mephentermine (3 mg IV). Dexmedetomidine is a better agent for prevention of shivering after spinal anesthesia as compared to ketamine and tramadol. It also provides adequate sedation and improves the surgical conditions.

Dexmedetomidine is effective and comparably better than tramadol or ketamine in preventing shivering after spinal anesthesia. Dexmedetomidine also provides sedation without respiratory depression and favourable surgical conditions. However, with its use a fall in blood pressure and heart rate is anticipated [13].

Shivering, a common intraoperative problem under spinal anesthesia increases the oxygen consumption considerably and is uncomfortable and distressing to the patient, anesthesiologist as well as surgeon. The present study was designed to explore the effectiveness of tramadol, clonidine and dexmedetomidine in the treatment of post spinal anesthesia shivering and to look for their adverse effects.

This prospective, randomized, double blinded control study was done on 90 patients who developed shivering under spinal anesthesia. They were randomly allocated into three groups with Group T receiving tramadol 1mg.kg-1, Group C getting clonidine 1mcg.kg-1 and Group D patients receiving dexmedetomidine 0.5mcg.kg-1. The time taken to control shivering, recurrence rate, hemodynamic variables, sedation score and adverse effects were observed.

Dexmedetomidine was faster in the control of shivering in 5.7±0.79minutes (min) whereas tramadol took 6.76±0.93min and clonidine was slower with 9.43±0.93min. The recurrence rate was much lower in the dexmedetomidine group with 3.3% than for clonidine (10%) and tramadol (23.3%) group. The sedation achieved with dexmedetomidine was better than clonidine and tramadol. The tramadol group had more cases of vomiting (four) and dexmedetomidine group had six cases of hypotension and two cases of bradycardia. Two of the clonidine patients encountered bradycardia and hypotension.

Dexmedetomidine is better than tramadol and clonidine in the control of shivering because of its faster onset and less recurrence rate. Though complications are encountered in the dexmedetomidine group, they are treatable [14]. Shivering during spinal anesthesia is a frequent complication and is induced by the core-to-peripheral redistribution of heat. Nefopam has minimal side effects and prevents shivering by reducing the shivering threshold. Electroacupuncture is known to prevent shivering by preserving the core body temperature. We compared the efficacies of electroacupuncture and nefopam for the prevention of shivering during spinal anesthesia.

Ninety patients scheduled for elective urological surgery under spinal anesthesia were enrolled in the study. Patients were randomly divided into the control group (Group C, n=30), the electroacupuncture group (Group A, n=30), and the nefopam group (Group N, n=30). Groups C and A received 100 ml of isotonic saline intravenously for 30 minutes before spinal anesthesia, while Group N received nefopam (0.15 mg/kg) mixed in 100 ml of isotonic saline. Group A received 30 minutes of electroacupuncture before receiving anesthesia. Shivering scores, mean arterial pressure, heart rate, body temperature and side effects were recorded before, and at 5, 15, 30, and 60 minutes after spinal anesthesia.

The incidence of post anesthetic shivering was significantly lower in Group N (10 of 30) and Group A (4 of 30) compared with that in Group C (18 of 30) (P<0.017). Body temperature was higher in Group N and Group A than in Group C (P<0.05). Hemodynamic parameters were not different among the groups.

By maintaining body temperature during spinal anesthesia, electroacupuncture is as effective as nefopam in preventing postanesthetic shivering [15].

Shivering is an unpleasant experience after spinal anesthesia. We conducted this study to evaluate the efficacy of ondansetron, ketamine and tramadol for prevention of shivering. In this randomized controlled study, 120 patients aged 18-65 years of American Society of Anesthesiologist (ASA) physical status I and II undergoing various surgical procedures were included and allocated alternately to one of the 4 groups; Normal saline (Group1), Ondansetron 4 mg (Group2), Ketamine 0.25 mg/kg (Group3) and Tramadol 0.5 mg/kg (Group4). Incidence of shivering, effect on hemodynamics, nausea, vomiting, sedation and emergence reactions were recorded. Data was analyzed using SPSS (The Statistical Package for Social Sciences) version 20.0 software.

The patients were comparable in terms of demographic variables, baseline temperature, type of surgery, median level of sensory blockade, duration of surgery and anesthesia. Shivering was present in 17 (56.7%), 5 (16.7%), 3 (10%) and 3 (10%) patients respectively in Group 1, 2, 3 and 4 which was statistically significant when compared to Group 1 (P=0.00) The odds of NS and ondansetron, NS and ketamine, NS and tramadol was 6.53, 11.76 and 11.76 respectively which showed that study drugs were effective in preventing shivering. None of the patients were sedated in Group 1 and 2. Mild to moderate sedation was present in Group 3 and 4 (P=0.00). None of the patients had drug related adverse reactions.

Prophylactic use of ondansetron, low doses of ketamine and tramadol is effective in preventing shivering post spinal anesthesia without untoward effects [16]. There

are significant physiologic differences between spinal and epidural anesthesia. Consequently, these two types of regional anesthesia may influence thermoregulatory processing differently. Accordingly, in volunteers and in patients, we tested the null hypothesis that the core-temperature thresholds triggering thermoregulatory sweating, vasoconstriction, and shivering are similar during epidural and spinal anesthesia.

Six male volunteers participated on three consecutive study days: epidural or spinal anesthesia were randomly assigned on the 1st and 3rd days (approximately T10 level); no anesthesia was given on the 2nd day. On each day, the volunteers were initially warmed until they started to sweat, and subsequently cooled by central venous infusion of cold fluid until they shivered. Mean skin temperature was kept constant near 36 degrees C throughout each study. The tympanic membrane temperatures triggering a sweating rate of 40 g.m-2.h-1, a finger flow less than 0.1 ml/min, and a marked and sustained increase in oxygen consumption (approximately 30%) were considered the thermoregulatory thresholds for sweating, vasoconstriction, and shivering, respectively. Twenty-one patients were randomly assigned to receive epidural (n = 10) or spinal (n = 11) anesthesia for knee and calf surgery (approximately T10 level). As in the volunteers, the shivering threshold was defined as the tympanic membrane temperature triggering a sustained increase in oxygen consumption.

The thresholds and ranges were similar during epidural and spinal anesthesia in the volunteers. However, the sweating-to-vasoconstriction (inter-threshold) range, the vasoconstriction-to-shivering range, and the sweating-to-shivering range all were significantly increased by regional anesthesia. The shivering thresholds in patients assigned to epidural and spinal anesthesia were virtually identical.

Comparable sweating, vasoconstriction, and shivering thresholds during epidural and spinal anesthesia suggest that thermoregulatory processing is similar during each type of regional anesthesia. However, thermoregulatory control was impaired during regional anesthesia, as indicated by the significantly enlarged inter-threshold and sweating-to-shivering ranges [17].

Both accidental and perioperative hypothermia are common in the elderly. The elderly are at risk because their responses to hypothermia may be delayed or less efficient than in those of younger subjects. For example, the vasoconstriction threshold during isoflurane anesthesia is approximately 1 degree C less in elderly than younger patients.

However, the extent to which other cold defenses are impaired in the elderly remains unclear, especially in those older than 80 yr. Operations suitable for spinal anesthesia provided an opportunity to quantify shivering thresholds in patients of varying ages. Accordingly, the hypothesis that the shivering threshold is reduced as a function of age during spinal anesthesia was tested.

Twenty-eight ASA Physical Status 1-3 patients undergoing lower extremity orthopedic procedures were studied. Spinal anesthesia was induced without pre anesthetic medication, using bupivacaine sufficient to produce a dermatomal level near T9. Electrocardiogram signals were recorded at 10-min intervals. Subsequently, an observer masked to patient age and core temperature identified the onset of sustained electromyographic artifact consistent with shivering. The tympanic membrane temperature triggering shivering identified the threshold.

Three patients did not shiver at minimum core temperatures exceeding 36.2 degrees C. Fifteen patients aged<80 yr (58 +/- 10 yr) shivered at 36.1 +/- 0.6 degrees C; in contrast, ten patients aged > or = 80 yr (89 +/- 7 yr) shivered at a significantly lower mean temperature, 35.2 +/- 0.7 degrees C (P=0.002). The shivering thresholds in seven of the ten patients older than 80 yr was less than 35.5 degrees C, whereas the threshold equalled or exceeded this value in all younger patients (P=0.0002).

Age-dependent inhibition of autonomic thermoregulatory control in the elderly might be expected to result in hypothermia. That it usually does not suggests that behavioral regulation (e.g., increasing ambient temperature, dressing warmly) compensates for impaired autonomic control. Elderly patients undergoing spinal anesthesia, however, may be especially at risk of hypothermia because low core temperatures may not trigger protective autonomic responses. Furthermore, hypothermia in the elderly given regional anesthesia may not be perceived by the patient (who typically feels less cold after induction of the block), or by the anesthesiologist (who does not observe shivering).

Consequently, temperature monitoring and management usually is indicated in these patients [18]. The purpose of this study is to assess whether the application of preoperative forced air warming set to high temperature (>43°C) for brief period can increase temperature on admission to the post anesthesia care unit (PACU) and prevent hypothermia or shivering during holmium laser enucleation of the prostate performed under spinal anesthesia.

Fifty patients were enrolled were assigned randomly to receive passive insulation (control group, n=25) or forced-air skin surface warming for 20 min before spinal anesthesia (pre-warming group, n=25). The primary outcome was temperature at PACU admission.

The pre-warming group had a significantly higher temperature on admission to the PACU than the control group (35.9°C [0.1] vs 35.6°C [0.1], P=0.023; 95% confidence interval of mean difference, 0.1°C-0.5°C). The trend of decreasing core temperature intraoperatively was not different between groups (P=0.237), but intraoperative core temperature remained approximately 0.2 °C higher in the pre-warming group (P=0.005). The incidence of hypothermia on admission to the PACU was significantly lower in the pre-warming group (56% vs 88%, P=0.025). Shivering occurred in 14 patients in the control group, and 4 patients in the pre-warming group (P=0.007).

Brief pre-warming at 45°C increased perioperative temperature and decreased the incidence of hypothermia and shivering. However, it was not sufficient to modify the

decline of intra operative core temperature or completely prevent hypothermia and shivering. Continuing pre-warming to immediately before induction of spinal anesthesia or combining pre-warming with intraoperative active warming may be necessary to produce clearer thermal benefits in this surgical population [19].

Heat loss and core-to-peripheral redistribution of body heat occur in patients undergoing neuraxial anesthesia resulted to decrease of core temperature and early reach of shivering threshold. Because shivering has deleterious metabolic and cardiovascular effects, it should ideally be prevented by pharmacologic or other means. Tizanidine is an alpha-2 agonist. We evaluated the usefulness of oral tizanidine (TI) and tramadol in preventing of shivering in patients undergoing spinal anesthesia for transurethral resection of the prostate (TURP).

Ninety patients, scheduled for TURP with spinal anesthesia, were prospectively enrolled. Patients were randomly assigned to 1 of 3 groups. 90 min before spinal anesthesia, 30 patients received 4 mg oral TI, 30 patients received 50 mg tramadol, and 30 patients received placebo as control group. Spinal anesthesia was induced at the L3-L4 or L4-L5 interspaces with 12.5 mg bupivacaine. An investigator blinded to the drugs recorded the frequency and degree of shivering.

The overall frequency and severity of shivering were significantly lower in patients treated with TI and tramadol compared to placebo (P=0.04) (P=0.001). There was not much difference in the nausea and vomiting of both the drugs (P=026) (P=011). There was no difference in hemodynamic parameters between three groups (P=0.08) (P=013).

Oral TI and tramadol were comparable in respect to their effect in decreasing the incidence, intensity shivering when used prophylactically in patients who underwent TURP with spinal anesthesia [20]. The passage from shore to marine life is a critical step in the development of juvenile penguins and is characterized by a fuel selection towards lipid oxidation concomitant to an enhancement of lipid-induced thermogenesis. However, mechanisms of such thermogenic improvement at fledging remain undefined. We used two different groups of pre-fledging king penguins (Aptenodytes patagonicus) to investigate the specific contribution of cold exposure during water immersion to lipid metabolism. Terrestrial penguins that had never been immersed in cold water were compared with experimentally cold-water immersed juveniles. Experimentally immersed penguins underwent ten successive immersions at approximately 9-10°C for 5 h over 3 weeks. We evaluated adaptive thermogenesis by measuring body temperature, metabolic rate and shivering activity in fully immersed penguins exposed to water temperatures ranging from 12 to 29°C. Both never-immersed and experimentally immersed penguins were able to maintain their homeothermy in cold water, exhibiting similar thermogenic activity. In vivo, perfusion of lipid emulsion at thermoneutrality induced a twofold larger calorigenic response in experimentally immersed than in never-immersed birds. In vitro, the respiratory rates and the oxidative phosphorylation efficiency of isolated muscle mitochondria were not improved with cold-water immersions. The present study shows that acclimation to cold water only partially reproduced the fuel selection towards lipid oxidation that characterizes penguin acclimatization to marine life [21].

The alterations in properties of mitochondria and of plasma membrane of brown adipose tissue and skeletal muscle of cold-acclimated rats are reviewed in order to bring out any adaptive changes which are related to the mechanism of nonshivering thermogenesis, and thus to the enhanced calorigenic action of catecholamines known to exist in these animals. Since prevention of the morphological changes in the mitochondria by treatment of the animals with oxytetracycline during acclimation to cold also prevents the development of the enhanced calorigenic response to the catecholamines it is concluded that the changes noted are either a cause of the development of the increased capacity for nonshivering thermogenesis during acclimation to cold or are secondary to the operation of nonshivering thermogenesis [22].

Recent human studies have shown that cold exposure increases lipid oxidation, even when the oxidation of circulating free fatty acid (FFA) is markedly reduced by the ingestion of nicotinic acid, thus seriously questioning the importance of FFA for lipid oxidation in the cold-exposed humans. It was therefore hypothesized that similarly to prolonged exercise, fatty acids from plasma triglycerides (TG) are important energy substrates for oxidation during prolonged cold exposure in man. The goal of this study was to determine the influence of cold exposure on an index of plasma TG utilization, the intravenous fat tolerance test (IVFTT). To evaluate the possibility of a delayed increase in fat tolerance, a second cold exposure and an IVFTT were also performed 24 hours after the first cold exposure. Seven healthy males (fasting, seminude) were subjected to an IVFTT (1 mL/kg 10% Intralipid) on three occasions while resting for 160 minutes: (1) at 29°C, (2) in the cold (10°C, 1 m/s wind), and (3) at 10°C 24 hours after the first cold test. One week separated the warm test from the cold tests. Cold exposure reduced mean body temperature by 3.4±0.1°C and increased energy expenditure 2.5 times in comparison to warm values (P<0.01). It also increased fat oxidation by 70% (P<0.05) and plasma glycerol levels (P<0.05), but did not alter fat tolerance. Although the second cold test entailed essentially the same changes in body temperatures and heat production as the first one, the second cold test was accompanied by a further increase in fat utilization (132% above warm values, P<0.01), slightly higher plasma glycerol levels, and an unchanged fat tolerance. The results of the present study demonstrate that cold exposure in humans significantly increases the oxidation of lipid, and that plasma TG do not appear to be an important energy substrate in the cold, even when lipid metabolism is further increased by the second cold test. It is suggested that white adipose tissue TG and intramuscular TG, not plasma TG, are the preferred sources of fatty acids for oxidation in cold-exposed humans [23].

Conclusion

Cold exposure in humans significantly increases the oxidation of lipid. Intravenous Lipid Emulsion (Intralipid, Lipofundin, etc.) treatment of shivering after spinal anesthesia is first suggested in the medical literature.

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