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Original Research Article

A Hospital Based Clinical Assessment of the Impact of Hypotensive Epidural Anesthesia on Distal and Proximal Tissue Perfusion in Patients Undergoing Total Hip Arthroplasty

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Abstract

Aim: To investigate tissue oxygenation in a clinical setting, using non-invasive near-infrared spectroscopy.

Methodology: The study conducted in the Department of Anesthesiology, IGIMS, Patna,Bihar, India for one year.Patients aged 18 to 70 years undergoing THA under HEA were enrolled. Data on patient demographics (age, gender, ethnicity, comorbidities) and intraoperative events (fluid balance, duration of surgery) were recorded. SmO_2 was measured by continuous sampling of non-invasive near- infrared spectroscopy (NIRS) at two standardized locations above and below the level of neuraxial blockade [(a) deltoid and (b) vastus lateralis of the quadriceps femoris muscle]. Stroke volume (SV) and CO were recorded continuously using a validated non-invasive bioreactance monitor. Other continuously recorded parameters included heart rate (HR), invasive mean arterial pressure (MAP) and arterial oxygen saturation (SO_2). The observation period was divided into quintiles to facilitate analysis.

Results: Average age of the patients was 58.37±14.6 years. Mean BMI was 25.84±6.44 Kg/m2. 40% were males and 60% were females. Mean procedure time was 134.3±15.8 minutes. Notably, no patients had significant cardiopulmonary disease and only four cases were there who had hypertension, hyperlipidemia or rheumatoid arthritis. From the unadjusted regression analysis, we found an intermittent and significant decline of mean SmO_2 in the vastus lateralis muscle during the first part of the surgical procedure in patients undergoing THA using HEA (nadir 2nd quintile: 71.07% vs. 63.33%, $p<0.0001$). Mean HR showed a modest but significant increase over the same period [66.18 (SD ± 9.08) vs. 74.59 bpm (SD ± 7.64); p=0.0001, respectively]. No significant change was seen for mean CO over time [3.55 (SD ± 0.68) vs. 4.08 L/min (SD ± 1.28); p=0.0515, respectively].

Conclusion: The study showed a significant unadjusted decrease of muscle tissue oxygenation saturation of the vastus lateralis muscle in patients undergoing THA using HEA. The SmO_2 in the deltoid muscle remained unaffected. Except changes in MAP, no other studied covariates impacted significantly on outcomes. Therefore, further research with a larger number of patients is needed to determine if these findings are of clinical significance.

Keywords: Vastus Lateralis, Spectroscopy, Deltoid, Arthroplasty.

Introduction

Total hip arthroplasty (THA) is one of the most cost-effective and consistently successful surgeries performed in orthopedics. It provides reliable outcomes for patients suffering from end-stage degenerative hip osteoarthritis. Specifically, it results in pain relief, functional restoration, and improved quality of life. Total hip arthroplasties (THA) are performed more than 280,000 times per year in the United States with predictions for this number to more than triple within 20 years [1,2]. Increasing evidence suggests that neuraxial anesthesia may be associated with better outcomes as compared to general anesthesia [3,4], especially in regard to perioperative blood loss and risk for thromboembolic events. Although the mechanisms by which this effect is achieved are not fully understood, data suggest that neuraxial anesthesia induced sympatholysis is a major contributor [4,5].

Extensive spinal anesthesia was used in the USA in the 1920s [6] and in Britain in the 1940s [7] for surgery of the abdomen and thorax. Although it provided a dry surgical field, the technique was abandoned because of circulatory and respiratory difficulties. Later, a dry surgical field using hypotensive anesthesia has been provided by vasodilators or cardiac depressants under general anesthesia (GA) [8]. The purpose of developing hypotensive epidural anesthesia (HEA) for THR was to combine the virtues of reduced intraoperative blood loss from induced hypotension with the lower risk of postoperative deep-vein thrombosis and thromboembolism associated with epidural anesthesia [9-11].

However, anemia and intraoperative blood loss in particular are considered predictors of postoperative outcome [12,13]. In this context, postoperative anemia is not only associated with a poorer outcome, but also with an increase in the complication rate and a prolonged hospital stay. Nevertheless, if it is necessary to transfuse a red cell concentrate; due to symptomatic postoperative anemia, there are risks for the patient. Studies have reported that postoperative blood transfusions after elective arthroplasty of the knee and hip not only increase the risk of serious complications and surgical infections, but might also lead to an increase in mortality [12,13]. Hypotensive epidural anesthesia not only reduces intraoperative blood loss, but is associated with a parallel reduction in transfusion requirements. In a retrospective study of patients receiving THR in 1986 and 1988, patients who had normotensive general or spinal anesthesia and did not donate autologous blood required 1.2 units of homologous blood, whereas those receiving HEA received 0.6 units-a 50% reduction [14].

However, little data exists to detail the effect of hypotensive epidural anesthesia on differential tissue oxygenation changes above and below the level of neuraxial blockade. Therefore, we sought to measure muscle tissue oxygen saturation (SmO2) as a marker of tissue perfusion above and below the level of sympatholysis under conditions of HEA in THA patients [15]. This study was designed to investigate tissue oxygenation in a clinical setting, using non-invasive near-infrared spectroscopy.

Methodology

The study conducted in the Department of Anesthesiology, IGIMS, Patna, Bihar, India for one year. Patients aged 18 to 70 years undergoing THA under HEA were enrolled. Data on patient demographics (age, gender, ethnicity, comorbidities) and intraoperative events (fluid balance, duration of surgery) were recorded. SmO_2 was measured by continuous sampling of non-invasive near- infrared spectroscopy (NIRS) at two standardized locations above and below the level of neuraxial

blockade [(a) deltoid and (b) vastus lateralis of the quadriceps femoris muscle]. Stroke volume (SV) and CO were recorded continuously using a validated non-invasive bioreactance monitor. Other continuously recorded parameters included heart rate (HR), invasive mean arterial pressure (MAP) and arterial oxygen saturation (SO_2). The observation period was divided into quintiles to facilitate analysis.

All patients were under the care of one anesthesiologist experienced in HEA. After establishing monitoring according to the ASA standards, additional monitoring for the study was applied as described above. Combined spinal/epidural anesthesia (CSE) was administered using bupivacaine 0.5% 2.5 cc intrathecally. For sedation purposes, midazolam 5 mg and adequately titrated propofol to achieve sedation but maintain spontaneous respiration were used. Epidurally administered lidocaine 2% in 5 ml aliquots was used to achieve a mid-thoracic sympathetic level resulting in hypotension (goal: 50-55 mmHg). For the purpose of maintaining CO, normo-volemia was targeted and a low dose epinephrine intravenous infusion was used as per institutional HEA protocol [1].

Results

We enrolled a total of 50 patients undergoing THA under HEA in this study. Average age of the patients was 58.37±14.6 years. Mean BMI was 25.84±6.44 Kg/m2. 40% were males and 60% were females. Mean procedure time was 134.3±15.8 minutes. Notably, no patients had significant cardiopulmonary disease and only four cases were there who had hypertension, hyperlipidemia or rheumatoid arthritis.

Table 1: Patient related demographics. Data is presented as mean and standard deviation (SD).

Patient related demographics	
Average age (years)	58.37±14.6
BMI kg/m2	25.84±6.44
Sex (female/male)	78/52
Procedure time (min)	134.3±15.8
Intraoperative fluid (mL)	1532 + 332

From the unadjusted regression analysis, we found an intermittent and significant decline of mean SmO_2 in the vastus lateralis muscle during the first part of the surgical procedure in patients undergoing THA using HEA (nadir 2nd quintile: 71.07% vs. 63.33%, $p<0.0001$). This decline was followed by a return to baseline towards the end of the surgery (71.02% vs. 69.14%, $p=0.343$). In contrast, mean SmO_2 did not change for the same period of time in the deltoid muscle. When analyzing vital parameters, we found a significant decline of MAP during surgery followed by a return to the initial values [65.56 vs. 66.16 mmHg; $p=0.903$], respectively,); mean HR showed a modest but significant increase over the same period [66.18 (SD ± 9.08) vs. 74.59 bpm (SD ± 7.64); $p=0.0001$, respectively]. No significant change was seen for mean CO over time [3.55 (SD ± 0.68) vs. 4.08 L/min (SD ± 1.28); $p=0.0515$, respectively].

In the adjusted regression analysis, significant changes in SmO_2 with respect to baseline were identified for the first part of the surgical procedure. There was no significant influence of other variables on SmO_2.

Table 2: Vital parameters and muscle tissue oxygen saturation (SmO_2) for upper (deltoid muscle) and lower extremity (vastus lateralis muscle). This table displays the means (plus standard deviation) for vital parameters and muscle tissue oxygen saturation for each quintile. (q0 represents baseline; qX: quintile 0-5).

	SmO_2[Deltoid, %]	SmO_2 [Vastus lateralis, %]	HR [bpm]	Psys [mmHG]	Pdia [mmHG]	MAP [mmHG]	SpO_2 [%]	CO [L/min]
q0	70.04 (8.82)	71.02 (9.13)	66.18 (9.08)	89.04 (20.92)	51.39 (11.31)	65.56 (14.28)	97.81 (2.20)	3.55 (0.68)
q1	70.36 (7.66)	66.34 (12.39)	68.21 (6.78)	80.49 (14.17)	46.72 (8.45)	58.79 (10.21)	97.66 (2.11)	3.64 (0.70)
q2	71.07 (8.63)	63.30 (12.59)	71.76 (7.62)	77.77 (8.26)	45.31 (5.43)	56.63 (5.73)	97.84 (2.06)	3.79 (0.84)
q3	70.79 (7.47)	64.23 (10.90)	72.07 (6.67)	80.13 (6.99)	45.81 (5.59)	57.69 (4.66)	97.99 (1.72)	3.78 (0.88)
q4	71.30 (7.32)	67.16 (7.61)	74.97 (5.29)	84.56 (7.92)	47.25 (3.89)	59.86 (2.78)	98.28 (1.45)	3.89 (1.06)
q5	69.70 (7.11)	69.14 (8.17)	74.59 (7.64)	95.45 (14.79)	50.85 (4.58)	66.16 (7.29)	98.48 (1.76)	4.08 (1.28)

Discussion

HEA offers many advantages in total hip replacement (THR), including a low rate of venous thromboembolism and a low postoperative mortality rate [16]. There is also radiographic evidence of improved prosthetic fixation when HEA is used [17]. Risks of this technique include high epidural or total spinal anesthesia and the potential for profound hypotension and severe bradycardia [18].

In this study evaluating changes in SmO_2 above and below the level of sympathetic blockade in patients undergoing THA under HEA, we found a significant decline of SmO_2 of the vastus lateralis muscle but not the deltoid, suggesting differential effects on tissue perfusion for the different locations of measurement. Reasons for this finding will have to remain speculative at this point, they include the following possibilities: NIRS equipment was attached to the dependent thigh as to avoid interfering with surgery and in the assumption that external manipulation of the area would be minimal [19].

However, compression of blood vessels may still occur during the surgical procedure by positioning posts or due to kinking of vessels during dislocation of the hip joint. Alternatively and in addition, dislocation of the hip and positioning may be associated with increased abdominal pressure thus impeding venous return, which in turn may decrease micro perfusion in the context of already decreased arterial pressure. All circumstances mentioned above may contribute to the observed decrease in SmO_2 in the lower extremity [19].

SmO_2 was maintained in the deltoid despite a reduction in MAP. While not affected by the sympathectomy of the neuraxial blockade, this finding suggests that the interventions applied to achieve HEA also preserve above the level of blockade. Thus our results suggest that concerns of hypoperfusion of levels above the sympathetic block during HEA are unfounded, at least in the context of our practice.

HEA has a number of clinical benefits for patients undergoing primary total joint arthroplasty. Lowering the mean arterial pressure (MAP) to 50 mmHg has been found to decrease intraoperative blood loss by up to 40% [20] and reduce

postoperative drainage blood volume [21]. HEA can be used in patients with hypertension, ischemic heart disease and in the elderly due to consistent central venous pressure, stroke volume and cardiac output. In addition, the cardiac, renal or cerebral functions are not affected by HEA [22]. Reports on negative side effects of HEA are rare, and include temporary decline in postoperative cognitive, hepatic or renal function [23,24].

Conclusion

The study showed a significant unadjusted decrease of muscle tissue oxygenation saturation of the vastus lateralis muscle in patients undergoing THA using HEA. The SmO_2 in the deltoid muscle remained unaffected. Except changes in MAP, no other studied covariates impacted significantly on outcomes. Therefore, further research with a larger number of patients is needed to determine if these findings are of clinical significance.

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