J Anesth (2015) 29:544–550
DOI 10.1007/s00540-015-1990-3

ORIGINAL ARTICLE

Post-dural puncture headaches following spinal drain placement during thoracoabdominal aortic aneurysm repair: incidence, associated risk factors, and treatment

Sean P. Riley · Melanie J. Donnelly · Didi Khatib · Christopher Warren · Kristopher M. Schroeder

Received: 18 May 2014 / Accepted: 14 February 2015 / Published online: 5 March 2015

Abstract

Purpose Spinal drains are used as a neuroprotective measure during thoracoabdominal aortic aneurysm (TAA) repair. Unfortunately, these drains can cause post-dural puncture headaches (PDPH). While PDPH following spinal anesthesia have been thoroughly evaluated, limited data exists about the incidence and risk factors for PDPH following spinal drains. Additionally, the efficacy of treatment with conservative therapies and epidural blood patches (EBP) for PDPH secondary to spinal drains has not been well documented.

Methods Data on 235 patients receiving spinal drains for scheduled TAA repair and surviving to discharge between January, 2005 and July, 2012 at the University of Wisconsin Hospitals and Clinics were retrospectively reviewed. The following data were extracted from the patient medical record: patient demographics, pre-existing medical conditions, spinal drain details, PDPH presentation, PDPH treatment methods, and success of treatments used. This data was then analyzed for statistical significance.

Results Of 235 patients, 43 (18.3 %) developed PDPH. Younger age ($p < 0.001$) and history of preoperative headache ($p \leq 0.001$) were found to increase the risk of PDPH. Use of EBP, either as the primary treatment, or following failed conservative therapy, was found to be a more effective treatment for PDPH than conservative therapies alone ($p = 0.017$).

Conclusions Spinal drain placement carries a risk of PDPH, as supported by an 18.3 % PDPH incidence in this study. Younger patients and/or patients with a history of chronic headache are at elevated risk for PDPH. Treatment using EBP, either as primary therapy or following unsuccessful conservative therapies, is a significantly more effective treatment than conservative therapies alone.

Keywords Post-dural puncture headaches · Epidural blood patch · Thoracoabdominal aortic aneurysm repair · Spinal drain

S. P. Riley (✉) · M. J. Donnelly · K. M. Schroeder
Department of Anesthesiology, University of Wisconsin School of Medicine and Public Health, 600 Highland Avenue, B6/319 CSC, Madison, WI 53792, USA
e-mail: spriley2@wisc.edu

D. Khatib
Department of Anesthesiology, Medical College of Wisconsin, 9200 West Wisconsin Avenue, Milwaukee, WI 53226, USA

C. Warren
Proteovista LLC, 510 Charmany Drive, Suite 57, Madison, WI 53719, USA

Introduction

The risk of paraplegia following thoracoabdominal aortic aneurysm (TAA) repair remains a significant concern for patients, vascular surgeons, and anesthesiologists [1–8]. Individual patient risk is variable and impacted by factors such as aneurysm extent, history of previous aortic surgery, presence of aortic aneurysm rupture or acute aortic dissection, history of pre-existing medical conditions (i.e., diabetes) and the surgical approach chosen (i.e., open versus endovascular approach) [5]. Although necessary, the use of aortic cross-clamping during open TAA repair appears to place patients at elevated risk of paralysis because it often leads to increased cerebrospinal fluid (CSF) pressure, which can secondarily reduce spinal cord perfusion [3]. Spinal drains, which increase cord perfusion by intentionally draining CSF, have therefore become a popular neuroprotective technique [6]. However, because spinal drains necessitate a large needle, they also place patients at elevated risk for subsequent CSF leak, CSF hypotension and the development of post-dural puncture headaches (PDPH) [9, 10]. Presentation of PDPH symptoms typically occurs approximately 48 h following dural puncture and traditionally most are thought to spontaneously resolve within 1 week [10]. However, PDPHs following spinal drain placement and CSF drainage are potentially debilitating, may not resolve within a reasonable time period secondary to the size of the dural tear and therefore often require medical treatment to allow for adequate postoperative ambulation. Treatment of PDPH can include conservative therapies (i.e., patient positioning, analgesics, hydration, caffeine, opioids) or more invasive treatment with epidural blood patches (EBP). Although PDPH have been well studied following dural puncture from spinal or epidural anesthesia, the incidence and risk factors for PDPH secondary to dural puncture with larger need lesor in the setting of intentional CSF drainage has not been well documented. Furthermore, although an EBP is the gold standard for the treatment of PDPH secondary to neuraxial anesthesia, there is little data comparing the efficacy of EBP and conservative therapy for treatment of PDPH following spinal drain placement and CSF drainage. Therefore, the purpose of this study was to evaluate predisposing factors and treatment success of PDPH at a large academic medical center where spinal drains are routinely utilized as a neuroprotective strategy for TAA repair.

Materials and methods

Approval by the University of Wisconsin Health Sciences Institutional Review Board was obtained prior to the collection and analysis of clinical data. The charts of 235 patients who received preoperative spinal drain placement and survived to discharge following elective TAA repair at the University of Wisconsin Hospitals and Clinics between January 18, 2005 and July 21, 2012 were reviewed. Patient age ranged from 19 to 89 years old. Patients who received spinal drains for reasons other than elective TAA repair were excluded from the study. Inpatient and outpatient records were analyzed and data on demographics (age, gender, BMI), pre-existing medical conditions (diabetes, smoking history, preoperative headaches), baseline pain score, American Society of Anesthesiologists (ASA) score, preoperative opioid use, method of TAA repair (open versus endovascular), spinal drain details (needle size and kit used, number of dural punctures, first recorded CSF pressure within 15 min, volume of CSF drained), duration of hospitalization and development of PDPH were recorded for all patients. Time of hospitalization was calculated from the time of spinal drain placement until discharge. For patients who developed PDPH, the following was also recorded: types of conservative therapy attempted, success of conservative therapy, blood volume if an EBP was used, EBP success, and need for a repeat EBP. All data were recorded in a spreadsheet on a password-protected department computer.

On the day of their TAA repair, all patients were brought to the operating room where they were sedated with midazolam and fentanyl as needed to facilitate spinal drain placement. Patients were placed in the lateral decubitus position. The lumbar region was cleansed with a 2 % chlorhexidine and 70 % isopropyl alcohol solution and allowed to dry before a drape was placed. The ALimitorr Volume Limiting CSF Drainage System kit (Integra Lifesciences Corporation, Plainsbory, NJ, USA) was utilized for CSF drainage and collection. A 14–18-gauge Tuohy needle was advanced into either the L3–L4 or L4–L5 interspace until CSF was obtained. In most cases, a 14-G Tuohy needle was utilized for drain placement and only in cases of difficult intrathecal space access were smaller needles used. Fluoroscopy was utilized, as needed, for guidance during this process. A 16–19-g catheter was then advanced to the T9–T10 spinal level under fluoroscopy before the Tuohy needle was removed. Free flow of clear CSF through the catheter was ensured and the first recorded CSF pressure within 15 min of spinal drain placement was recorded. Sterile dressings were then used to cover the insertion site prior to surgery. In the setting of TAA repair, CSF was drained as needed to maintain a CSF pressure below 6 mmHg intra-operatively during thoracic artery occlusion and reperfusion and 10 mmHg post-operatively [11]. In the setting of endograft procedures, spinal fluid pressure was reduced to below 10 mmHg prior to device deployment [12]. Post-operatively, the spinal drain was maintained until both bilateral lower extremity function and absence of neurological complications were observed for at least 24 h. Spinal drain removal commonly occurred 2–3 days post-operatively.

Both inpatient and outpatient records were reviewed for PDPH presentation. This either involved mention of a PDPH in the patient records or mention of a headache within 1 week of spinal drain placement that improved with patient positioning in the supine position and worsened when patients assumed a more upright position.

Patient records and orders were reviewed for mention of treatment with conservative therapy or EBP and data about each and their efficacy was recorded. Conservative therapy consisted of assuming a supine position (i.e., bed rest), oral or intravenous (IV) fluid therapy, oral or IV caffeine, analgesics such as acetaminophen and non-steroidal anti-inflammatory drugs (NSAIDs) and opioids. When needed, EBP was performed within one level of the lumbar interspace used for spinal drain placement. As tolerated, patients

Table 1 Post-operative day that post-dural puncture headache first presented

Days after surgery	N	% of PDPH
N/A	1	2.3
0	1	2.3
1	3	7.0
2	10	23.3
3	14	32.6
4	7	16.3
5	2	4.7
6	5	11.6

PDPH post-dural puncture headache

were placed in the seated position. Following chlorhexidine skin prep and drape, a Perifix FX Continuous Epidural Anesthesia Tray kit (B. Braun Medical Inc., Bethlehem, PA, USA) was used to access the epidural space. Following loss of resistance, 10–34 ml of sterile autologous blood was slowly injected into the epidural space. Cessation of autologous blood injection occurred after a predetermined volume had been injected or upon significant patient complaint of back pressure. Patients were then instructed to maintain a supine position for 1 h following procedure completion.

For the primary outcome, Fisher's exact test using two-tails was used to determine whether there existed a significant difference ($p > 0.05$) in the efficacy of treatment between use of conservative therapies and an EBP for PDPH. The incidence of PDPH is reported as a percentage of all patients evaluated. Incidence of successful treatment is reported as a percentage of all patients who received that treatment. Student's t tests were used to determine the significance for the following: age, BMI, total CSF drained, and hospital time. Fisher's exact tests were used to determine the significance and confidence intervals for: gender (male), diabetes (yes), smoking history (yes), preoperative headaches (yes), preoperative opioid consumption (yes), and TAA procedure type (open versus endovascular surgical procedure). Mann–Whitney U tests were used to determine the significance and confidence intervals of the following: ASA score, preoperative pain score, number of dural punctures, and first recorded CSF pressure. All statistical tests were performed using two-tails.

Table 2 Age of patients with and without presentation of a post-dural puncture headache

Age (years)	+PDPH		−PDPH		% PDPH/total	
	N	% Total	N	% Total	N	%
<20	1	2.3	0	0.0	1/1	100
20–30	3	7.0	2	1.0	3/5	60
30–59	14	32.6	31	16.1	2/9	31.1
Total <60	18	41.9	33	17.2	18/51	35.3
≥60	25	58.1	158	82.3	25/183	13.7
Total	43	–	192	–		18.3

PDPH post-dural puncture headache

Table 3 Risk factors for the development of a post-dural puncture headache

Risk factor	+PDPH	−PDPH	P value
N	43	192	
Age (years)**	59.0 ± 17.4	69.4 ± 11.5	0.000
Preoperative headaches (yes)**	27.9 %	8.3 %	0.001
Gender (male)	62.8 %	55.2 %	0.399
BMI	26.7 ± 5.1	28.7 ± 14.1	0.385
ASA score	3.3 ± 0.8	3.5 ± 0.6	0.215
Smoking (yes)	23.8 %	25.8 %	0.848
Diabetes mellitus (yes)	11.6 %	10.4 %	0.787
Preoperative pain score (0–10)	1.3 ± 0.5	1.5 ± 0.7	0.515
Preoperative opioid consumption (yes)	19.0 %	18.3 %	1.000
Surgical procedure (open TAA repair)	62.8 %	71.9 %	0.270
Needle size (gauge)	14.3 ± 1.0	14.7 ± 1.3	0.387
Number of dural holes created	1.4 ± 0.8	1.3 ± 0.6	0.586
First recorded cerebrospinal fluid pressure (mmHg)	13.1 ± 7.1	14.3 ± 6.8	0.388
Total cerebrospinal fluid drained (ml)	203.6 ± 140.1	213.9 ± 153.1	0.690

** Significant

PDPH post-dural puncture headache, *BMI* body mass index, *ASA* American Society of Anesthesiologists, *TAA* thoracoabdominal aortic aneurysm

Table 4 Efficacy of treatments used for post-dural puncture headache

	Conservative therapy	Epidural blood patch
N	30	19
#Successful	19	18
#Failed	11	1
#Failed conservative therapy receiving EBP	9	–
% Efficacy**	63.3 %	94.7 %

** Significant

EBP epidural blood patch

Table 5 Types of conservative therapies attempted

Type of conservative therapy attempted	Number of patients	% Of total conservative therapy patients
N	30	–
Bed rest (supine positioning)	13	43.3
Hydration (oral or intravenous)	8	18.6
Analgesics (Tylenol, acetaminophen, NSAIDs)	6	20.0
Stitch placement	1	3.3
Caffeine (oral or intravenous)	10	33.3
Opioids	4	13.3

Results

Of the 235 patients who received spinal drains for their TAA repair, 43 (18.3 %) developed a PDPH. The mean day of PDPH presentation was post-operative day (POD) 3 (Table 1). Patients who developed a PDPH were found to be significantly younger (59.0 ± 17.4 vs. 69.4 ± 11.5; $p < 0.001$) than those who did not. The incidence of PDPH development was 35.3 % in patients under 60 years of age as compared to only 13.7 % for patients who were 60 years of age or older at the time of spinal drain placement (Table 2). Patients who had a history of preoperative headaches were more likely to develop a PDPH than those who did not (27.9 vs. 8.3 %; $p \leq 0.001$). No differences in PDPH incidence were found in this population based on other patient- or spinal drain-related factors (Table 3).

Of the 43 patients who developed a PDPH, 30 were initially treated with conservative therapy. In total, 19 patients were treated using EBP. Nine patients received EBP following failed conservative therapy and ten patients received an EBP as the primary method of treatment (Table 4). Treatment using EBP as either the primary treatment method modality or secondary to unsuccessful conservative therapy was found to be a significantly more effective treatment for PDPH than use of conservative therapy alone (94.7 vs. 63.3 %; $p = 0.017$). Of the 19 patients receiving an EBP, only one required a repeat EBP to achieve successful treatment resolution of PDPH symptoms. The mean volume of blood used for EBP was 19 ml (Table 5).

Discussion

The main finding of this study is that the incidence of PDPH is 18.3 % among patients who received a spinal drain as a neuroprotective measure during elective TAA repair. Further analysis revealed that younger patients and those with a history of chronic headache were at elevated risk for developing a PDPH. Patients under the age of 60 had an incidence of PDPH (35.3 %) greater than 2.5 times that of patients 60 years of age and older (13.7 %). While previously published manuscripts have commented on the incidence and limited risk factors for the development of PDPH following spinal drain placement, this is the first to more fully characterize risk factors in patients where CSF is aggressively drained to improve spinal cord perfusion [4, 9]. This study also demonstrates that more aggressive CSF drainage strategies may result in an increased incidence of PDPH symptoms. In addition, this study compares the efficacy of conservative measures to alleviate PDPH symptoms following spinal drain placement with the efficacy of EBP and their ability to rescue failed conservative therapy.

A number of neuroprotective strategies have been reported to decrease the incidence of complications following TAA repair [1–3, 5, 7]. The current popularity of spinal drains is largely related to the simplicity of the technique, their dual application in both elective and emergency procedures, as well as the fact that they represent a minimally invasive perioperative method of maintaining spinal cord perfusion [3]. Although no neuroprotective method has completely eliminated the risk of paralysis following TAA repair, several studies have demonstrated promising risk reduction when spinal drains are combined with other neuroprotective measures [5, 7]. Studies by Acher et al. and Safi et al. [13, 14] demonstrated that significant reductions in postoperative neurologic deficits can be achieved with perioperative spinal fluid drainage.

Despite the benefits of CSF drainage during TAA repair, spinal drain placement is not without risk. Complications such as meningitis, abducens nerve palsy, catheter fracture, direct spinal cord injury, subdural hematoma, intracranial hemorrhage, and persistent CSF leak have been reported to occur in 5 % of all cases [4, 6]. While this data was not collected as part of this study specifically focusing on PDPH, a previous study conducted at the same institution found a 1 % incidence of neurologic complications and a mortality of 0.6 % from complications related to spinal fluid drainage [11]. The large size of the needle used for spinal drain placement logically increases the likelihood of CSF leak and subsequent headache development [9, 10]. Unfortunately, PDPHs can be debilitating secondary to symptoms, which can include migraine-like features (i.e., nausea, photophobia, phonophobia), vertigo, tinnitus, low back pain, and diplopia [15]. As many as 39 % of PDPH patients report difficulty carrying out activities of daily living for at least a week following presentation [15]. Developing an understanding of the incidence and risk factors for PDPH development secondary to spinal drain placement is therefore a significant concern for physicians and their patients.

Previous studies have demonstrated that younger age, female gender, lower body mass index (BMI), history as a non-smoker, and a history of chronic headaches increase the risk of PDPH development [10, 15–18]. The decreased risk in older patients is theorized to result from factors such as lower CSF pressure, reduced elasticity of the dura mater, and reduced extradural space, all of which may resist CSF leakage [15, 18]. In the current study, the age effect was very strong, especially when patients were divided into groups based on age over or under 60.

A higher PDPH incidence in women may be secondary to estrogen-related vasodilation of cerebral arteries and resulting CSF hypotension. An elevated BMI and subsequent increase in intra-abdominal pressure has been associated with a reduced incidence of PDPH. In the current study, we were unable to identify gender or increased BMI as factors significantly related to an increased incidence of PDPH in patients following spinal drain placement. This lack of significance may be due in part to our limited sample size or the gender distribution of patients presenting for TAA repair. Among patients under the age of 60, 62.7 % were male while only 37.3 % were female.

Dodge et al. [10] reported that non-smoking patients were 3.3 times more likely to develop a PDPH than smokers following dural puncture for CSF sampling. The decreased incidence may be related to the coagulation-inducing effects of smoking, which may aid in sealing the dural puncture site and reducing CSF leakage [10]. In our review, a history of smoking was not found to significantly impact the incidence of PDPH.

Larger needles create a larger dural rent and logically have been associated with an increased risk of PDPH. Interestingly, a study of 504 patients, where a 14-G Tuohy needle was used for spinal drain placement, reported a PDPH incidence of only 9.7 %. Despite the use of a similar needle gauge for spinal drain placement, they reported a PDPH incidence that is nearly half of the 18.3 % incidence we discovered. This difference may be related to how PDPHs were diagnosed. In addition, CSF pressure goals and the CSF drainage plans for patients in our study were more aggressive (goal of CSF pressure <6 mmHg during thoracic artery occlusion and reperfusion in open procedures/<10 mmHg during endovascular procedures and <10 mmHg until patients were awake with normal leg lift) which may account for the increased incidence of PDPH symptoms [11]. Similar to the study by Youngblood et al. and previous studies of dural puncture for CSF sampling and spinal anesthesia, we too found that patients who developed PDPH were significantly younger. Additionally, our study also identified a history of chronic headaches as a risk factor for development of a PDPH following spinal drain placement.

While the risk of serious complications related to low intracranial CSF pressure is generally low, the high morbidity typically found among PDPH patients makes identifying efficacious treatment methods a considerable concern for both physicians and their patients. Conservative therapies are often considered first and typically include: encouraging maintenance of a supine position (i.e., bed rest), oral or IV hydration therapy, analgesics (i.e., acetaminophen, NSAIDs), oral or IV caffeine and opioids. Although these therapies may aid in controlling symptoms until the headache eventually resolves, their efficacy as a treatment of PDPH remains controversial. While bed rest and hydration therapy are often recommended by physicians, there exists a lack of evidence for their efficacy [16, 17]. Analgesics have proven successful in the relief of symptoms and in reducing the need for more aggressive therapies. However, evidence of their success in the treatment of PDPH is lacking. Many physicians have advocated treatment of PDPH with caffeine secondary to its vasoconstrictive properties. However, studies supporting the sustained efficacy of caffeine therapy are currently lacking [17, 19].

EBP has therefore become the gold standard in the treatment of PDPH following dural puncture [16]. Relief of PDPH symptoms is thought to occur via compression of the dural sac and elevation in intracranial pressure, as well as formation of a clot at the site of the dural hole preventing further CSF leakage [16, 17]. Although injection of other fluids (i.e., dextran, saline) into the epidural space has been shown to improve PDPH symptoms, their effect is often transient due to an inability to prevent further CSF leakage [16, 17].

In our study, the mean volume of blood injected for EBP was 19 ml (range, 10–34 ml), but the majority of patients received 20-ml injections. The success rate for EBP as a treatment for PDPH following dural puncture with large, 14–18-G Tuohy needles was 94.7 % in our study. In addition, EBP was found to be a more effective treatment for PDPH than use of conservative therapies (94.7 vs. 63.3 % success). Therefore, our results suggest that routine use of EBP as the primary treatment method for PDPH may be a superior approach relative to conservative therapies. However, some PDPH patients may be ineligible for treatment with an EBP due to a history of prior medical conditions (i.e., sepsis, coagulopathy) [16]. Additionally, some patients may have reservations about receiving an EBP due to reports of serious but rare complications [16, 17].

Because PDPHs are often associated with severe morbidity, developing a better understanding of what constitutes an efficacious treatment method or plan can help physicians properly treat their patients should a PDPH develop. An understanding of risk factors that place patients at elevated risk for development of a PDPH may allow physicians to accurately predict, consent, and monitor patients for the development of headache symptoms. In the current study, use of an EBP was discovered to be a more effective method of resolving PDPH symptoms than use of conservative therapies. These results suggest that use of EBP as the primary treatment method may offer patients a quicker resolution of symptoms.

The current analysis has several limitations that deserve further attention. The retrospective nature of the current review certainly introduces the possibility of bias. While both inpatient and outpatient records were thoroughly reviewed, there exists a chance that some data may potentially have been missing or inaccurately recorded during charting. Additionally, because PDPHs have only recently been identified as a common complication of spinal drain placement, headache symptoms may potentially have been under-reported in earlier patients within our study. Therefore, the actual incidence of PDPH may be higher than estimated. In addition, connective tissue disorders (i.e., Marfan syndrome, Ehlers–Danlos syndrome, etc.), the classification of aortic aneurysm repaired and non-PDPH spinal drain-related complications were not recorded, and this may impact the incidence of PDPH or success of therapy. Due to a limited sample size, similar studies with a much larger sample size would be required before any results could be generalized to the larger population.

References

1. Weigang E, Sircar R, von Samson P, Hartert M, Siegenthaler MP, Luehr M, Richter H, Szabo G, Czerny M, Zentner J, Beyersdorf F. Efficacy and frequency of cerebrospinal fluid drainage in operative management of thoracoabdominal aortic aneurysms. Thorac Cardiov Surg. 2007;55:73–8.
2. Leyvi G, Ramachandran S, Wasnick J, Plestis K, Cheung AT, Drenger B. Case 3-2005 risk and benefits of cerebrospinal fluid drainage during thoracoabdominal aortic aneurysm surgery. J Cardiothorac Vasc Anesth. 2005;19:392–9.
3. Afifi S. Pro: cerebrospinal fluid drainage protects the spinal cord during thoracoabdominal aortic reconstruction surgery. J Cardiothorac Vasc Anesth. 2002;16:643–9.
4. Estrera AL, Sheinbaum R, Miller CC, Azizzadeh A, Walkes JC, Lee TY, Kaiser L, Safi HJ. Cerebrospinal fluid drainage during thoracic aortic repair: safety and current management. Ann Thorac Surg. 2009;88:9–15.
5. Wallace L. Con: cerebrospinal fluid drainage does not protect the spinal cord during thoracoabdominal aortic reconstruction surgery. J Cardiothorac Vasc Anesth. 2002;16:650–2.
6. Sinha AC, Cheung AT. Spinal cord protection and thoracic aortic surgery. Curr Opin Anaesthesiol. 2010;23:95–102.
7. Weaver KD, Wiseman DB, Farber M, Ewend MG, Marston W, Keagy BA. Complications of lumbar drainage after thoracoabdominal aortic aneurysm repair. J Vasc Surg. 2001;34:623–7.
8. Lima B, Nowicki ER, Blackstone EH, Williams SJ, Roselli EE, Sabik JF, Lytle BW, Svensson LG. Spinal cord protective strategies during descending and thoracoabdominal aortic aneurysm repair in the modern era: the role of intrathecal papaverine. J Thorac Cardiovasc Surg. 2012;143:945–52.
9. Youngblood SC, Tolpin DA, LeMaire SA, Coselli JS, Lee VV, Cooper JR. Complications of cerebrospinal fluid drainage after thoracic aortic surgery: a review of 504 patients over 5 years. J Thorac Cardiovasc Surg. 2013;146:166–71.
10. Dodge DS, Ekhator NN, Jefferson-Wilson L, Fischer M, Jansen I, Horn PS, Hurford WE, Geracioti TD. Cigarette smokers have reduced risk for post-dural puncture headache. Pain Physician. 2013;16:E25–30.
11. Wynn MM, Mell MM, Tefera F, Hoch JR, Acher CW. Complications of spinal fluid drainage in thoracoabdominal aortic aneurysm repair: a report of 486 patients treated from 1987 to 2008. J Vasc Surg. 2009;49:29–35.
12. Bobadila JL, Wynn M, Tefera G, Acher CW. Low incidence of paraplegia after thoracic endovascular aneurysm repair with proactive spinal cord protective protocols. J Vasc Surg. 2013;57:1537–42.
13. Acher CW, Wynn MM, Hoch JR, Popic P, Archibald J, Turnipseed WD. Combined use of cerebral spinal fluid drainage and naloxone reduces the risk of paraplegia in thoracoabdominal aneurysm repair. J Vasc Surg. 1994;19:236–46.
14. Safi HJ, Hess KR, Randel M, Iliopoulos DC, Baldwin JC, Mootha RK, Shenaq SS, Sheinbaum R, Greene T. Cerebrospinal fluid drainage and distal aortic perfusion: reducing neurologic complications in the repair of thoracoabdominal aortic aneurysms types I and II. J Vasc Surg. 1996;23:223–8.
15. Bezov D, Lipton RB, Ashina S. Post-dural puncture headache: part I diagnosis, epidemiology, etiology, and pathophysiology. Headache. 2010;50:1144–52.
16. Ghaleb A. Postdural puncture headache. Anesthesiol Res Pract. 2010;2010:102967.
17. Bezov D, Ashina S, Lipton R. Post-dural puncture headache: part II-prevention, management, and prognosis. Headache. 2010;50:1482–98.

18. Amorim JA, de Gomes Barros MV, Valenca MM. Post-dural (post-lumbar) puncture headache: risk factors and clinical features. Cephalagia. 2012;32:916–23.
19. Sechzer PH, Abe L. Post-spinal anesthesia headache and treatment with caffeine: evaluation with demand method. Part I. Curr Ther Res. 1976;24:307–12.