의학석사 학위논문

파열성 또는 비파열성 뇌동맥류 수술을 위한 전측두 두개골 절제술에서 수술 부위 폐쇄적 흡입 배액관 삽입의 유용성

The efficacy of surgical site suction drain insertion in fronto-temporal (pterional) craniotomy for ruptured or unruptured cerebral aneurysm

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이 논문을 의학석사 학위 논문으로 제출함

2022년 2월

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Summary

Background: Cerebral aneurysm is one of the most common cerebrovascular disorders encountered by neurovascular surgeons. Fronto-temporal(pterional) craniotomy, designed and popularized by Yasargil in the 1970s, is the most commonly used approach for cerebral aneurysm surgery. During the last decades, surgical closed suction drains are widely used in various surgical specialties to reduce complications caused by postoperative fluid collection. However, only a scarce literature investigated the efficacy of surgical site suction drain in fronto-temporal(pterional) craniotomy for treating cerebral aneurysm.

Methods: We performed a retrospective review of fronto-temporal(pterional) craniotomies for ruptured or unruptured cerebral aneurysm at our center between January 2006 and December 2020. We obtained data on the presence of surgical closed suction drain, the occurrence of epidural hematoma (EDH) requiring evacuation, and the occurrence of surgical site infection (SSI). We performed univariate and multivariate logistic regression analyses to determine the risk factors associated with EDH requiring evacuation and SSI, including the use of suction drain.

Results: A total of 5,287 fronto-temporal(pterional) craniotomies in 5,147 patients performed. Subgaleal suction drain was inserted for 1,613 craniotomies in 1,597 patients. Suction drain was not inserted for 3,674 craniotomies in 3,550 patients. The presence of ruptured aneurysm and duration of operation were associated with EDH requiring evacuation ($P < 0.001$, $P < 0.001$, respectively). The presence of ruptured aneurysm was associated with SSI ($P < 0.001$). However, the presence of surgical suction drain was not associated with the occurrence of EDH requiring evacuation or SSI ($P = 0.918$, $P = 0.406$, respectively).

Conclusion: Our study found that the use of surgical site suction drains does not affect the

occurrence of EDH requiring evacuation or SSI. Thus, the routine use of surgical site suction drain for pterional craniotomy in cerebral aneurysm operation is not recommended.

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Introduction

The frontotermporal craniotomy or pterional craniotomy, which was popularized by Yasargil in the mid1970, is the workhorse of the supratentorial approaches.[1, 2] Neurosurgeons prefer it because of its simplicity, flexibility, efficiency, and familiarity. This corridor is the most commonly used surgical route for treating cerebral aneurysm. As with other craniotomies, this surgical approach has risk of developing epidural and/or subgaleal hematoma due to bone bleeding from the drilled sphenoid ridge, bleeding or oozing from the detached temporalis muscle. Thus, many centers place the surgical site suction drains to prevent the occurrence of these hematoma.

Surgical closed suction drains are frequently utilized in a variety of surgical specialities to minimize postoperative fluid collection and to aid wound healing. In the 1960s, Jackson and Pratt, the 2 neurosurgeons from the naval hospital in California, developed a silicon closed suction drain for patients with subdural hematoma.[3, 4] This drain provided sterility and a reliable method of measuring output volumes. The Jackson-Pratt drain is still a common choice among surgeons of many specialties today. There are several research that surgical site suction drain prevents the occurrence of fluid collection or bleeding that causes complications[5, 6], and that surgical site suction drain, a foreign body, promotes infection.[7] However, there is only a scarce literature investigating the effect of these drain on the surgical complications of cranial surgery.

We retrospectively reviewed varying patterns of practice within our institution with respect to the use of subgaleal drains for patients undergoing frontotermporal (pterional) craniotomy for the treatment of cerebral aneurysm. The purpose of this study was to investigate whether the use of subgaleal drains affect the occurrence of epidural hematoma

(EDH) requiring evacuation and surgical site infection (SSI).

Methods

1. *Study population*

Patients were included from a database of operative cases at Asan Medical Center between January 2006 and December 2020. The patients who underwent pterional craniotomy and clipping surgery for unruptured or ruptured cerebral aneurysm were included. Cases of posterior circulation aneurysm clipping through suboccipital craniotomy, deaths within 14 days, those who underwent craniotomy extension due to brain swelling were excluded. Cases with coagulopathy or those who underwent cerebral revascularization surgery were also excluded because the operation time may be prolonged, which could give a bias to the study. We divided patients into subgaleal drainage group (SGD) and non-drain group (ND). Institutional Review Board approval was obtained for this single-institution retrospective study with waiver of informed consent due to retrospective nature of the study.

2. *Clinical & radiologic data collection and evaluation*

Demographic variables were retrospectively obtained from electronic medical records. Sex, age, weight, height, and body mass index (BMI) were collected. Diabetes mellitus (DM), arterial hypertension, taking antiplatelet or anticoagulation agent, immunosuppressant use, smoking, duration of antibiotics use after surgery, and duration of operation were documented as variables to identify any significant confounding factors for surgical site infection, poor wound healing or epidural fluid collection or hematoma. Brain CT was taken

immediately after surgery and on the 3rd day after surgery, and additionally, CT/MR images were analyzed if necessary (e.g., severe headache, neurological deterioration, suspicious surgical site infection).

3. *Operative methods*

In elective cases, patients taking antiplatelet drugs or anticoagulants were instructed to discontinue the drugs 7 days before surgery. In patients taking anticoagulants, if the international normalized ratio (INR) was higher than 1.5 in the coagulation test performed the day before surgery, an antagonist or fresh fronzen plasma (FFP) was given to correct it to less than 1.5. In the case of emergency surgery, platelet transfusions were performed for patients taking antiplatelet drugs, and antagonists and FFPs were administered for patients taking anticoagulants so that INR could be maintained within the normal range.

All craniotomies were performed in the operating room using laminar air flow system. An intermittent pneumatic compression device was used for all patients to prevent deep vein thrombosis. Subcutaneous heparin or low-molecular weight heparin were not used in all the patients. All prophylactic antibiotics were initiated within one hour before scalp incision. All patients were administered with one of the antibiotics listed below; cefazolin, cefemandol, cefmetazole, ceftezole, ceftriaxone, cefuroxime, ciprofloxacin (in case of penicillin allergy_, or piperacillin-tazobactam (in case of the patients who had aspiration pneumonia). During surgery, antibiotics were administered repeatedly every 3 hours. In our center, post-operative prophylactic antibiotics were administered up to 4 days after surgery from January 2006 to January 2011 and for one day after January 2011, according to the domestic surgical policy. In the elective surgical cases, patients washed their hair and scalp with betadine soap the day before operation. Hair and scalp washing was not done in cases of patients who underwent emergent surgery, or had allergic reaction to betadine. The scalp was shaved in the following way to prepare the incision according to the surgeon's preference; whole shaving of fronto-

temporal area, or partial shaving (1–2 cm width along the marked incision). After shaving, incision site was prepared by alcohol and iodine derivatives solution and covered with iodine-impregnated incision drape Ioban® (3-M, St. Paul, MN). Watertight closure of the dura was done in all patients. Hemostasis was meticulously ensured at the end of the procedures. Jackson-Pratt drain, a surgical silicone drain, was placed along a gap between the bone flap and deep temporalis muscle fascia, and the tip of the drain tube was placed around removed lateral sphenoid wing to facilitate communication with epidural space. And then, distal end of the drain tube was connected to the trocar and scalp was tunneled and attached to the closed suction system (200mL bulb suction) . The wound was subsequently closed with interrupted sutures using vicryl 3-0 in subgaleal layer, and subcutaneous layer, followed by skin closure with nylon 2-0 sutures or staples. Most of cases, compressive dressings were applied.

4. *Postoperative management and outcomes*

The surgical site was checked on a daily basis, and the dressing was changed as well. Compression bandage was removed 24 hours after surgery. Every 8 hours subgaleal drain reservoir was emptied and the amount was measured. When the flow rate was less than 100 ml in the preceding 24 hours and less than 30 ml in the previous 8 hours, subgaleal drains were removed under sterile conditions. After a maximum of 48 hours, all drains are withdrawn, and the exit site is closed with a single suture. The tip of drain was cut off 2~3cm from its far end with aseptic scissors, and was sent to microorganism laboratory for cultural analysis. Sutures or staples on scalp were routinely removed on the postoperative day 7~10.

The following two outcome variables were recoreded; the occurrence of EDH requiring evacuation and the occurrence of SSI. SSI was defined as any of following; positive cultures from surgical samples, purulent or serous discharge from wound with local heat, erythema,

tenderness, subdural empyema, and wound breakdown which was defined as spontaneous or iatrogenic dehiscence of cutaneous layer requiring reapproximating. Revisional operation for epidural fluid collection or hematoma was performed in patients with focal neurologic deficit or severe headache due to mass effect.

5. *Statistical analysis*

All statistical analysis was performed using R Version 4.1.0 (R Foundation for Statistical Computing, Vienna, Austria). An independent-sample t-test and Mann-Whitney U-test were used for numeric variables, and the chi-squared test or Fisher's exact test were used for nominal variables. A *P* value less than 0.05 was considered statistically significant. Univariate and multivariate logistic regression analyses were conducted. The purpose of univariate analysis was to identify risk factors related to the occurrence of EDH requiring surgical removal or SSI. Multivariate analysis was performed with variables with *P* value less than 0.10 in univariate analysis and the presence of surgical drain.

Results

A total of 5,287 pterional craniotomies in 5,146 patients were performed for clipping of unruptured or ruptured aneurysm. SGD group included 1,613 craniotomies in 1,597 patients. Five-hundred-four (31.2%) craniotomies were performed in male patients and 1,109 (68.8%) craniotomies were performed in female patients and the male to female ratio was 1:2.2. The mean age of SGD was 55.9 (range, 24−88) years. ND group included 3,674 craniotomies in 3,550 patients. One-thousand-eighty-seven craniotomies were performed in male patients and 2,587 craniotomies were performed in female patients. The male to female ratio was 1:2.4. The mean age of NDG was 58.7 (range, 10-86). In the comparison of baseline demographics between the two groups, there were significant differences in age, the presence of aneurysm rupture, DM, antiplatelet or antithrombotic agent administration, duration of antibiotics use, and duration of operation ($P < 0.05$). The demographic data between SGD and ND group are detailed in table 1.

Table 1. Baseline characteristics of SGD group and ND group

Characteristics	SGD (n = 1,613)	ND (n = 3,674)	*P* value
Age, years, mean ± SD	55.9 ± 10.0	58.7 ± 13.6	< 0.001
Sex, male, n (%)	504 (31.2%)	1,087 (29.6%)	0.238
BMI, kg/m^2, mean ± SD	24.5 ± 3.2	24.5 ± 3.3	0.697
Hypertension, n (%)	775 (48.0%)	1,785 (48.6%)	0.741
Diabetes, n (%)	154 (9.5%)	148 (4.0%)	< 0.001
Smoking, n (%)	486 (30.1%)	1,052 (28.6%)	0.284
Presence of ruptured aneurysm, n (%)	288 (17.9%)	226 (6.2%)	< 0.001
Antithrombotic agent use, n (%)	262 (16.2%)	342 (9.3%)	< 0.001
Immunosuppressant use, n (%)	3 (0.2%)	9 (0.2%)	0.919
Antibiotics use > 1 day, n (%)	1,203(74.6%)	252 (6.9%)	< 0.001
Craniotomy side, right, n (%)	841 (52.1%)	1,987 (54.1%)	0.202
Duration of operation, minutes, mean ± SD	244.8 ± 73.3	238.6 ± 68.4	0.004

Abbreviations: SGD, Subgaleal drain; SD, standard deviation; BMI, Body Mass Index

1. EDH requiring evacuation

Among all cases, there were 13 cases (0.24%) had epidural fluid collection or hematoma requiring revision operation, and revisional operation was not required in 5,274 cases (99.76%). Significant differences found in presence of ruptured aneurysm between SGD and ND (table 2). The brain CT of representative case is shown in figure 1.

Univariate and multivariate analyzes were performed to determine the effect of drain and other factors on the occurrence of EDH requiring evacuation. In univariate analysis, the use of subgaleal drain did not affect the occurrence of EDH requiring evacuation (odd's ratio (OR) 1.96, 95% confidence interval (CI) 0.63–5.90, $P = 0.237$). However, the presence of ruptured aneurysm was significantly associated with higher risk of the occurrence of EDH requiring evacuation (OR 11.0, CI 3.53–34.2, $P < 0.001$). The longer duration of operation was also associated with higher risk of the occurrence of EDH requiring evacuation (OR 1.01, CI 1.00–1.21, $P = 0.002$). When these two risk factors were adjusted in multivariate analysis, the use of subgaleal drain was not associated with the occurrence of EDH (OR 1.06, CI 0.33–3.32, $P = 0.918$) (Table 3).

Figure 1. Brain CT of a case with post-operative EDH requiring evacuation.

Table 2. Comparison between the demographics of patients with and without EDH requiring evacuation

Characteristics	No EDH (n = 5,274)	EDH (n = 13)	*P* value
Age, years, mean ± SD	57.9 ± 12.7	56.5 ± 10.5	0.684
Sex, male, n (%)	1,586 (30.1%)	5 (38.5%)	0.722
BMI, kg/m^2, mean ± SD	24.5 ± 3.3	23.6 ± 2.9	0.296
Hypertension, n (%)	2,554 (48.4%)	6 (46.2%)	1.000
Diabetes, n (%)	301 (5.7%)	1 (7.7%)	1.000
Smoking, n (%)	1,533 (29.1%)	5 (38.5%)	0.661
Presence of ruptured aneurysm, n (%)	507 (9.6%)	7 (53.8%)	< 0.001
Antithrombotic agent use, n (%)	604 (11.5%)	0 (0%)	0.390
Immunosuppressant use, n (%)	12 (0.2%)	0 (0%)	1.000
Craniotomy side, right, n (%)	2,823 (53.6%)	5 (38.5%)	0.418
Duration of operation, minutes, mean ± SD	240.3 ± 69.4	317.7 ± 191.9	0.172

Abbreviations: SGD, Subgaleal drain; SD, standard deviation; BMI, Body Mass Index

Table 3. Univariate and multivariate analysis of factors influencing the occurrence of EDH requiring evacuation

	Univariate			Multivariate		
	OR	95% CI	*P* value	OR	95% CI	*P* value
Subgaleal drain insertion	1.96	0.63–5.90	0.237	1.06	0.33–3.32	0.918
Presence of ruptured aneurysm	11.0	3.53– 34.20	< 0.001	8.84	2.72– 29.96	< 0.001
Age	0.99	0.94–1.01	0.628	-	-	-
Male	1.45	0.44– 4.36	0.520	-	-	-
BMI	0.91	0.75– 1.08	0.283	-	-	-
Hypertension	0.91	0.29– 2.75	0.870	-	-	-
Diabetes	1.38	0.08– 7.02	0.769	-	-	-
Antithrombotic agent use	-	-	-	-	-	-
Craniotomy side	0.54	0.16– 1.63	0.808	-	-	-
Duration of operation	1.01	1.00– 1.21	0.002	1.01	1.00–1.01	0.001

Abbreviations: OR, Odd Ratio; CI, Confidence Interval; BMI, Body Mass Index.

2. SSI

There were 26 (0.49%) SSI in all cases. Between patients with SSI and patients without SSI, the proportion of male patients and patients with ruptured aneurysm were higher in SSI group than those without SSI ($P = 0.045$, $P < 0.001$, respectively) (Table 4). The brain MR of a representative case with postoperative epidural abscess is shown in figure 2.

Univariate and multivariate analyses were performed to find out the risk factors associated with SSI, including subgaleal drain insertion (Table 5). In univariate analysis, subgaleal drain insertion did not significantly affect the occurrence of SSI (OR = 1.96, CI 0.89–4.25, $P = 0.094$), but male patients and patients with ruptured aneurysm had higher risk of SSI ($P = 0.034$, $P < 0.001$, respectively). In multivariate analysis using these factors, only presence of ruptured aneurysm was significantly associated with the risk of SSI.

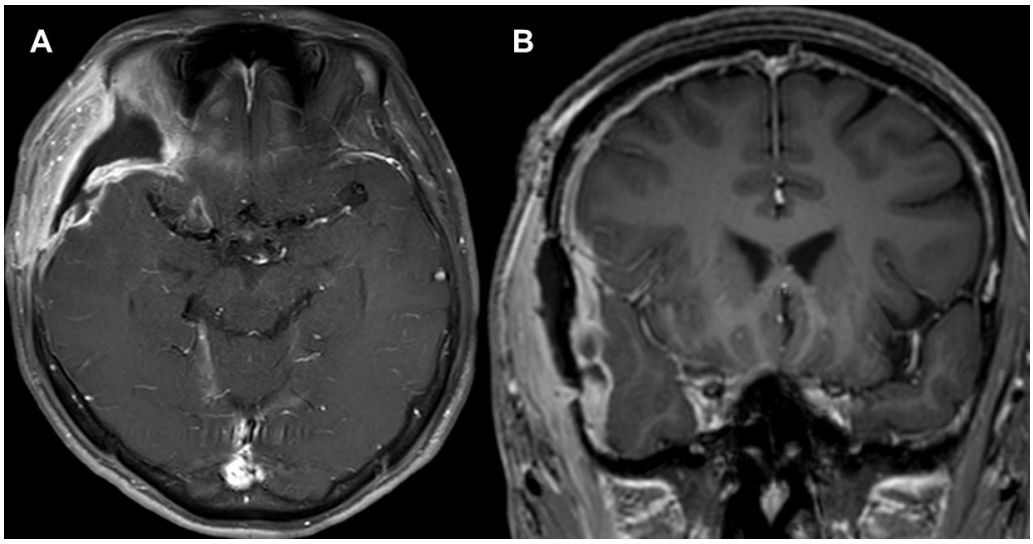

Figure 2. MR of a case with postoperative epidural abscess.

(A) T1 enhanced axial image, (B) T1 enhanced coronal image. About 6cm extent fluid collection with irregular thickened peripheral enhancement is observed around the operative site.

(A) T1 enhanced axial image, (B) T1 enhanced coronal image. About 6cm extent fluid collection with irregular thickened peripheral enhancement is observed around the operative site.

Table 4. Comparison between the demographics of patients with and without SSI

Characteristics	No SSI (n = 5,261)	SSI (n = 26)	*P* value
Age, years, mean ± SD	57.9 ± 12.7	54.7 ± 9.9	0.192
Sex, male, n (%)	1578 (30.0%)	13 (50.0%)	0.045
BMI, kg/m^2, mean ± SD	24.5 ± 3.2	25.3 ± 3.7	0.234
Hypertension, n (%)	2551 (48.5%)	9 (34.6%)	0.224
Diabetes, n (%)	299 (5.7%)	3 (11.5%)	0.390
Smoking, n (%)	1529 (29.1%)	9 (34.6%)	0.685
Presence of ruptured aneurysm, n (%)	504 (9.6%)	10 (38.5%)	<0.001
Antibiotics use > 1 day , n (%)	1444 (27.4%)	11 (42.3%)	0.141
Immunosupressant use, n (%)	12 (0.2%)	0 (0%)	1.000
Craniotomy side, right, n (%)	2817 (53.5%)	11 (42.3%)	0.343
Duration of operation, minutes, mean ± SD	240.4 ± 70.0	257.2 ± 60.0	0.223

SSI, Surgical Site Infection; SD, standard deviation; BMI, Body Mass Index

Table 5. Univariate and multivariate analysis of factors influencing the occurrence of SSI

	Univariate			Multivariate		
	OR	95% CI	*P* value	OR	95% CI	*P* value
Subgaleal drain insertion	1.96	0.89–4.25	0.094	1.41	0.62–3.00	0.406
Presence of ruptured aneurysm	5.9	2.57–12.9	<0.001	5.09	2.16–11.02	<0.001
Age	0.97	0.93–1.01	0.109	-	-	-
Male	2.33	1.07–5.09	0.034	2.16	0.99–4.95	0.051
BMI	1.07	0.95–1.19	0.332	-	-	-
Hypertension	0.56	0.24–1.24	0.332	-	-	-
Diabetes	2.16	0.51–6.26	0.332	-	-	-
Immunosuppressant use	-	-	-	-	-	-
Antibiotics > 1 day	0.52	0.24–1.15	0.105	-	-	-
Craniotomy side	0.64	0.28–1.38	0.252	-	-	-
Duration of operation	1.01	1.00–1.01	0.254	-	-	-

Abbreviations: OR, Odd Ratio; CI, Confidence Interval; BMI, Body Mass Index

Discussion

Our primary purpose in this work was to describe the efficacy of the use of subgaleal drain after pterional craniotomy for ruptured or unruptured cerebral aneurysm at a single institution. There was no evidence of statistically significant effect of insertion of subgaleal drain on epidural fluid collection or hematoma requiring revisional operation and SSI. We also found that presence of ruptured aneurysm was associated with epidural fluid collection or hematoma requiring revisional operation and SSI. Additionally, duration of operation was risk factor for epidural fluid collection or hematoma requiring revisional operation

We hypothesized that epidural fluid collection or hematoma may have occurred as a result of hemorrhage or fluid collection in the subgaleal space that flowed along a gap between the bone flap and skull. Therefore, we thought that the drain placed in the space would be effective in preventing the occurrence of EDH requiring evacuation. However, our results showed that subgaleal drain after pterional craniotomy does not prevent postoperative EDH requiring evacuation. According to Choi SY, In a study based on the data of 607 patients who had ruptured aneurysm clipped through pterional craniotomy, there were significantly more epidural hematomas in the drain group (22 cases (7.4%) and 8 cases (2.4%) in the NDG), but a total of 30 There were only 2 cases in which revision was required for epidural hematoma, and the drain did not affect the prevention of EDH requiring revision.[8] Our study is meaningful in that it analyzed including unruptured aneurysm cases differently from this study previously mentioned, and we present evidence with the largest volume among those studied so far.

In contradiction to our study, In a paper written in 250 pediatric cases who underwent

cerebral revascularization for moyamoya disease, patients with subgaleal drains had a reduced rate of epidural hematomas than those without drains(9.1% vs. 25.5%, p = 0.001).[6] In summary, our results suggest that insertion of subgaleal drain is not mandatory for preventing EDH requiring surgical evacuation.

In our study, subgaleal drain insertion was not associated with wound-related complications such as surgical site infection or wound dehiscence. According to a systematic review by Schipmann et al, the use of surgical drain was associated with surgical site infection.[7] We hypothesized that foreign material connected to an external space, such as a subgaleal drain tube, promotes surgical site infection. However, subgaleal drain insertion did not affect the incidence of SSI. According to Tackeun Kim et al, there was a result that significantly increased the occurrence of SSI when drain was maintained for more than 3 days.[9] In our study, it is assumed that these results were obtained because the drain was removed within a maximum of 48 hours. Therefore, if the drain is to be removed within 48 hours, there is no reason not to put it in for risk of SSI.

The presence of ruptured aneurysm and duration of operation were risk factors associated with EDH requiring evacuation, and the presence of ruptured aneurysm was also identified as a risk factor associated with SSI. In the case of ruptured aneurysm, the postoperative hemorrhagic risk was thought to be high because antiplatelet or anticoagulation agent could not be properly stopped before surgery, unlike elective surgical cases.[10, 11] In addition, the possibility of an increase in postoperative hemorrhagic complications due to imbalance of coagulation and fibrinolysis systems could be considered.[12] The duration of operation was another risk factor associated with EDH requiring evacuation. As the operation time increases, there is a high possibility of high intraoperative blood loss, as a result, a large amount of colloid infusion or blood transfusion was performed, interfering with normal hemostasis, so it was thought that this compication occurred.[13, 14] The presence of ruptured

aneurysm was significantly associated with the occurrence of SSI, which was thought to be because preoperative bathing using antimicrobial soap was performed the day before surgery in elective surgery cases, but it was not possible in ruptured cases.[14, 15] In addition, whole hair removal is performed in a ruptured case, and it is thought that microorginism entered and colonized through microtrauma of the scalp occurred during hair removal and thus caused SSI.[16]

Our study has several strengths. First, This study included the largest volume of patients with ruptured or unruptured cerebral aneurysm clipped through pterional craniotomy so far. Second, all patients underwent surgery at a single center by three experienced neurovascular specialists. This provides ubiquity to the technical aspects of surgery. Third, throughout the study period, the perioperative management policies (discontinuation of antiplatelet or anticoagulant agent, hemostasis, blood pressure control, wound dressing technique, etc) were consistent. To reduce potential bias, all electronic medical records and datas were reviewed by a person who did not work at the center during the study period. There were several limitations as well. First, this study has a retrospective design, and there is an inherent potential bias that occurs depending on the study design. Second, We subgaleal drain was not inserted in the second half of the study period, and this may be a potential bias according to time period. Thrid, the patient group could not be randomized. Therefore, to identify the true risk and benefit of subgaleal drain in patients undergoing pterional craniotomy, a well-designed, large, multicenter, prospective randomized controlled trial is needed.

Conclusion

Subgaleal drain insertion does not prevent epidural fluid collection or hematoma requiring surgical evacuation and does not increase the incidence of surgical site infections. Thus, the routine use of surgical site suction drain for pterional craniotomy in cerebral aneurysm operation is not recommended.

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Supplementary material

(In progress)

국문요약

뇌동맥류는 신경외과 뇌혈관전문 의사가 가장 흔하게 접하는 뇌혈관질환이다. 1970년대 Yasrgil에 의하여 고안되고 유명해진, 전-측두(pterional) 두개골 개두술은 뇌동맥류 수술을 위해 가장 흔하게 사용되는 접근법이다. 지난 몇 십년간 수술용 폐쇄 흡인 배액관은 수술 후 혈액 또는 체액 저류로 인한 합병증을 줄이기 위해 여러 수술 분과에서 사용되었다. 그러나, 뇌동맥류 수술을 위해 전-측두 두개골 개두술을 시행한 환자에서 사용된 이 배액관의 효능에 관해 연구한 논문은 극히 적다.

우리는 2006년 1월부터 2020년 12월까지 서울아산병원에서 시행한 뇌동맥류 수술을 위해 전-측두 개두술을 시행한 환자에 대하여 후향적 연구를 시행하였다. 우리는 수술용 폐쇄 흡인 배액관의 유무, 배액이 필요한 경막외 출혈의 발생 유무, 수술 부위 감염의 발생 여부에 관한 데이터를 수집하였다. 우리는 배액이 필요한 경막외 출혈의 발생, 수술 부위 감염의 발생과 관련된 위험 인자를 확인하고 배액관이 이러한 것에 영향을 주는지를 알기 위해 단일, 다중회귀분석을 시행하였다.

총 5,147명의 환자에서 총 5,287번의 전-측두 개두술을 시행하였다. 수술 부위 폐쇄 흡인 배액관은 총 1,597명의 환자에서 총 1,613번의 전-측두 개두술에서 삽입되었다. 수술 부위 폐쇄 흡인 배액관은 총 3,550명의 환자에서 시행한 총 3,674번의 전-측두 개두술에서 삽입되지 않았다. 파열된 뇌동맥류의 유무와 수술 시간이 배액이 필요한 경막외 출혈의 발생과 관련이 있었다($P < 0.001$, $P < 0.001$, 각각). 파열된 뇌동맥류의 유무는 수술 부위 감염과 관련이 있었다($P < 0.001$). 그러나, 수술 부위 폐쇄 흡인 배액관 유무는 배액이 필요한 경막외 출혈 또는 수술 부위 감염과 관계

가 없었다(P = 0.918, P = 0.406, 각각).

결론적으로 우리 연구는 수술 부위 폐쇄 흡인 배액관이 배액이 필요한 경막외 출혈 또는 수술 부위 감염에 영향을 미치지 않는다는 것을 확인하였다. 그리하여, 뇌동맥류 수술을 위한 전-측두 개두술시 수술 부위 폐쇄 흡인 배액관의 일상적인 사용은 추천하지 않는다.