Surgical Neurology International
OPEN ACCESS
For entire Editorial Board visit : http://www.surgicalneurologyint.com

Original Article

Benefits of early aneurysm surgery: Southern Iran experience

Abdolkarim Rahmanian, Mohammad Jamali, Ali Razmkon, Juri Kivelev[1], Rossana Romani[1], Ehsan-Ali Alibai, Juha Hernesniemi[1]

Shiraz Neuroscience Research Center, Department of Neurosurgery, Shiraz University of Medical Sciences, Nemazee Hospital, Shiraz, Iran, [1]Helsinki University Central Hospital, Topeliuksenkatu, Helsinki, Finland

E-mail: Abdolkarim Rahmanian - ak.rahmanian@gmail.com; Mohammad Jamali - jamalimo@sums.ac.ir; *Ali Razmkon - ali.razmkon@gmail.com; Juri Kivelev - Juri.Kivelev@hus.fi; Rossana Romani- rossana.romani@hus.fi; Ehsan-Ali Alibai - alibai@sums.ac.ir; Juha Hernesniemi - juha.hernesniemi@hus.fi
*Corresponding author

Received: 07 October 12 Accepted: 10 October 12 Published: 26 December 12

This article may be cited as:
Rahmanian A, Jamali M, Razmkon A, Kivelev J, Romani R, Alibai E, *et al*. Benefits of early aneurysm surgery: Southern Iran experience. Surg Neurol Int 2012;3:156.
Available FREE in open access from: http://www.surgicalneurologyint.com/text.asp?2012/3/1/156/105095

Abstract

Background: Neurovascular surgery has been practiced in Shiraz, the main referral center of the Southern Iran, for over 30 years; however, the trend has accelerated tremendously in recent years following subspecialization of neurovascular surgery in Shiraz, Department of Neurosurgery. Over 100 patients are operated each year, and nearly all are addressed during the first 72 hours after presentation.

Methods: In this paper, we focus on the description of techniques we apply for early clipping of ruptured intracranial aneurysms in the anterior circulation. Improvements in outcome, mortality, and rebleeding rates are also discussed.

Results: Mortality and rebleeding rates have declined significantly since the institution of new techniques.

Conclusion: The establishment of early surgery for ruptured anterior circulation aneurysms through the lateral supraorbital approach along with specific anesthetic protocol has resulted in significant improvement of morbidity, mortality, and rebleeding rates at our department.

Key Words: Anterior circulation, early surgery, ruptured aneurysm, techniques

Access this article online
Website: www.surgicalneurologyint.com
DOI: 10.4103/2152-7806.105095
Quick Response Code:

INTRODUCTION

One of the early complications of subarachnoid hemorrhage (SAH) due to ruptured intracranial aneurysm is rebleeding. Patients who survive after the initial hemorrhage are at risk for this deadly complication.[8] Prevention of rebleeding occurs by total isolation of the aneurysm from blood circulation either by open surgery or endovascular techniques.[3,10] The average annual mortality rate for SAH has shown a decreasing trend that is associated with new strategies such as early surgery within 72 hours after the onset of SAH.[16]

Shiraz University of Medical Sciences is the principal referral center of neurosurgery, and the only referral center for cerebrovascular surgery in Southern Iran. Neurovascular surgery has been practiced for over 30 years; however, as a result of subspecialization of neurovascular surgery in the department, the trend has accelerated tremendously recently. All ruptured aneurysms of the anterior circulation are treated during the first 72 hours after presentation in our center. We present details of the strategies and techniques we apply for early clipping of ruptured anterior circulation aneurysms, and will compare our results with results of cases operated earlier using a different strategy.

MATERIALS AND METHODS

Patient population

Department of neurosurgery of Shiraz University of Medical Sciences is the main referral center for aneurysm surgery in Southern Iran. All patients from the same province, and over 70% of patients from neighboring provinces refer to our center for treatment. This accounts for a referring population of 5.5 million people, and constitutes a sum of over 100 cases of documented intracranial aneurysms operated each year in our center. This gives an incidence rate of nearly two cases of SAH per 100,000 population per year.

Our previous treatment strategy of aneurysmal SAH earlier than 2010 in the majority of patients included delayed surgery using the pterional approach with an old neuroanesthetic protocol. Since 2010, we have been following an early surgery program using the lateral supraorbital approach and advanced neuroanesthesia (the Helsinki protocol) for nearly all patients.

Diagnosis

Diagnosis of SAH is performed using unenhanced brain computed tomographic scan (CT). Lumbar puncture is performed to rule out xanthochromia in the case of normal brain CT. Brain CT angiography (CTA) is requested at the next step, which shows intracranial aneurysm in over 95% of cases. If brain CTA is negative, four vessel angiography within 7-10 days is performed the next stage for diagnosis.

Most patients were in 45- to 55-year-old age group (male–female ratio =0.95). On admission, 56 patients (35%) presented with Hunt and Hess grade 1 and Fisher grade 3 (62.5%); and the most common location of the aneurysm was MCA (33%) [Table 1].[33]

Treatment strategy

Due to the better familiarity of our specialists with microsurgical clipping rather than endovascular techniques, most aneurysms undergo direct clipping in our center. Some patients are operated only a few hours after aneurysmal SAH but mostly are treated within the first 72hours of presentation.

Preparation before operation

All patients with aneurysmatic SAH are admitted to the ICU, and aggressive medical care and monitoring are provided. Noise, noxious stimuli (including intramuscular injections), and unnecessary visits are prohibited. Prophylactic anticonvulsant is given which usually includes phenytoin loading followed by maintenance dose. Sedation and analgesia are usually provided by benzodiazepines and morphine, respectively, in small dosages. Steroids, nimodipine, H_2 blockers, and stool softeners are ordered routinely. Triple H therapy (hypertension, hypervolemia, and hemodilution) is a standard, but such therapy may be fully instituted after successful elimination of the aneurysm.

Preparation of operating theater

In addition to routine equipments used for anesthesiology and microneurosurgery, other facilities dedicated to the field of vascular neurosurgery are utilized exclusively for aneurysm surgery. Operative microscope (OPMI Pentero, Carl Zeiss Company) is armed by indocyanine green (ICG) angiography. Microscope-integrated near-infrared indocyanine green videoangiography (ICG-VA) can provide reliable information about residual parts and the patency of important branches and perforators.[5–7] Intraoperative Doppler sonography is also performed routinely in most of the cases.

Positioning

The operating table arms with remote control for positional changes such as head up or down and table rotation to the right or left side. Jugular veins are checked to remain uncompressed. Belts are used to fix the patient to the operating table and pressure points are protected by pads and cushions. We place a roll under the patient

Table 1: Demographic, cinical, and outcome parameters in patients operated using the new and old protocols

Protocol (%)	New (%)	Old (%)
Number of patients operated	160	174
Number of aneurysms	205	204
Sex		
Male	78 (48.8)	66 (37.9)
Female	82 (51.2)	108 (62.1)
Multiple aneurysms	27 (16.9)	25 (14.4)
Age (mean, range)	55, 1–86	50, 17–80
Aneurysm location		
MCA	68 (33.2)	26 (15)
ACom	61 (29.8)	67 (38.5)
Others	76 (37.0)	81 (46.5)
Hunt & Hess Grade		
1	56 (35.0)	26 (14.9)
2	51 (31.8)	62 (35.6)
3	15 (9.4)	66 (38.0)
4	16 (10.0)	8 (4.6)
5	22 (13.8)	12 (6.9)
Fisher Grade		
1	26 (16.2)	25 (14.4)
2	21 (13.2)	50 (28.7)
3	100 (62.5)	80 (50.0)
4	13 (8.1)	19 (11.9)
GOS		
1	22 (13.8)	34 (19.5)
2	2 (1.3)	6 (3.5)
3	5 (3.1)	8 (4.6)
4	19 (11.8)	34 (19.5)
5	112 (70.0)	92 (52.9)

shoulder to provide a suitable position of the head above the cardiac level [Figure 1].

Approach

Our technique involve skull fixation in the three-point fixating head frame, elevation of the head above level of the heart and 15°–30° of head rotation with slight lateral tilting and extension [Figure 1].

Minimal shaving is performed and skin preparation with iodine solution and alcohol is done. An 8–10 cm frontotemporal skin incision is outlined by a surgical marker at least 1 cm behind the hairline until 2-3 cm above the zygomatic arch [Figure 2]. Subcutaneous injection of diluted epinephrine is performed in advance to optimize skin hemostasis. To avoid atrophy of the temporalis muscle and injury to the frontalis branch of the frontal nerve, muscle is incised not more than 1.5-2 cm in length, and it is elevated with the skin as a single one-layer flap. We use fishhooks for retraction of the flap to the front [Figure 3]. After retraction of flap, excellent exposure of the superior orbital rim and superior temporal line is achieved.

A single bur hole is placed just under the superior temporal line and a 3 by 4 cm free bone flap is elevated by craniotomy [Figures 4 and 5]. We use microdrill for drilling of the frontal side of sphenoid ridge. Dural opening is performed in a curvilinear fashion and dural flap is fixed by multiple stitches. At this point, microscope is brought to the field and is in use until the end of dural closure.

Neuroanesthesia

Administration of appropriate neuroanesthesia is one of the most important stages of operation. We have recently switched to the Helsinki protocol for neuroanesthesia,[34] which has been very effective in providing a relaxed brain. We use agents such as mannitol, lasix, remifentanil, and propofol. In case blood pressure drops, we start norepinephrine instead of tapering the

Figure 1: Patient's position during the lateral supraorbital approach. A roll is placed under the shoulder to provide a suitable position for the head above cardiac level. We perform skull fixation in the three-point fixator frame, and provide 15°–30° of head rotation with slight lateral tilting and extension

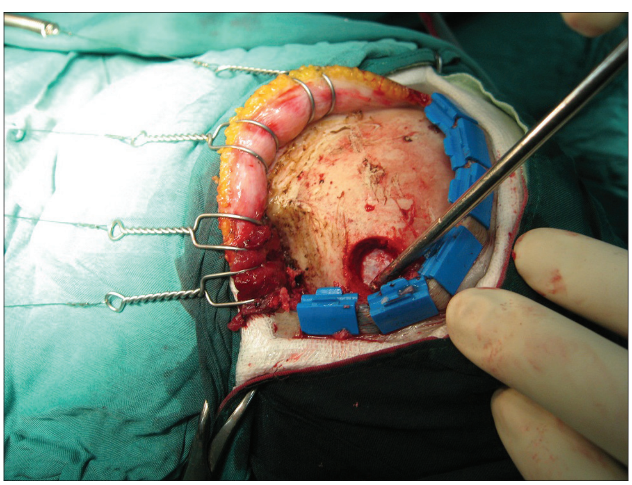

Figure 3: The temporalis muscle is incised not more than 1.5-2 cm in length, and it is elevated with the skin as a single one-layer flap. We use fishhooks for retraction of the flap to the front. A single bur hole is placed under the superior temporal line

Figure 2: An 8-10 cm frontotemporal skin incision is outlined by a surgical marker 1 cm behind the hairline until 2-3 cm above the zygomatic arch

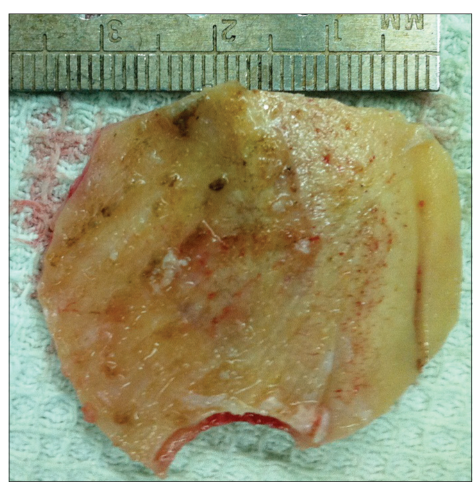

Figure 4: A 3 by 4 cm free bone flap is elevated by craniotomy

Figure 5: Postoperative three-dimensional CT scan of a patient who underwent the lateral supraorbital approach. Note the small size of the craniotomy and its relation to anatomic landmarks

dose of propofol and/or remifentanil. Sometimes brain relaxation is not achieved with such a combination, thus sodium thiopental is added. For maximal brain relaxation, opening of lamina terminalis and/or Liliequist membrane, and drainage of CSF is performed. Opening of the lamina terminalis is an easy way to CSF drainage and optimal brain relaxation.[24] In some severely swollen brain, ventriculostomy from Paine's point is performed to help further brain relaxation.[32]

Dissection

Meticulous dissection of sylvian fissure is performed. Intermittent water dissection is a proper option.[13,23,28] After release of the aneurysm from adhesions, an appropriate clip is selected. We usually use temporary clipping while releasing the aneurysm for about 3 min, not exceeding 5 min. The first clip is usually the pilot clip, and the appropriate permanent clip will be applied after complete aneurysm base visualization. Great care is taken under high magnification of microscope to preserve all branches and perforators. Blood flow of proximal and distal of aneurysm is checked by intraoperative ICG angiography and Doppler sonography after clipping. Usually, puncture and shrinkage of the aneurysm is done meticulously for good visualization of all branches. Intraoperative rupture of aneurysm is much less common when using temporary clipping (<10%). After finalizing the permanent clip, oxidized cellulose (surgicel)-soaked papaverin is placed *in situ* to relieve regional vasospasm.

Closure

Dura is closed meticulously under the microscope, and bone flap is fixed. Afterward, muscle, subcutaneous layer, and skin are repaired in three separate layers.

Postoperative course

The patient is transferred to the neurosurgical intensive care unit and the previously mentioned medications and care are continued. The patient is allowed to wake up gently, and postoperative brain CT scan will be performed a few hours after the operation. Follow-up brain CTA is performed routinely as soon as possible.

RESULTS

Comparing outcome measures [Table 1] in recently operated (new protocol) with previously treated (old protocol) patients, it becomes evident that mortality and rebleeding rates have declined significantly. Mortality rate, once reported to be as high as 40%,[1] and later calculated to be about 20%, is now reported to be about 14%, regardless of the significant increase in the number of high-grade patients (Hunt and Hess grade 4 and 5). Acute phase rebleeding used to occur in 10.5% of patients[1] while the incidence is now 1-2%, occurring most commonly in patients who have been referred with delay after 72 h. Interestingly, a significant number of rebleeding cases have occurred at the time or just before craniotomy.

Another significant change has occurred as a result of new Helsinki protocol for anesthesia. There is rarely a problem such as a swollen or tight brain, and drainage of CSF through the lamina terminalis yields very relax brains; whereas in the past, the problem of a tight brain required some partial frontal lobectomy for better exposure of the skull base. Postoperative brain contusion used to occur in significant number of our patients because of massive retraction in setting of edematous brain, and some of these cases needed reoperation (decompressive craniectomy or lobectomy). The incidence of such situations is now extremely rare.

DISCUSSION

The incidence rate of SAH is different around the world. The highest rates have been reported to occur in Finland and Japan (21.4 and 27 per 100,000 person per year; respectively), almost three times as high as in the other parts of the world.[21,25] An earlier study performed in our department showed that the rate of SAH was approximately one per 100,000 population.[1,33] New data suggest an annual rate of 2 per 100,000, which is still much less than the reported worldwide rate of 10 per 100,000.[25] Such an increase is mainly due to better diagnosis and referral. We believe that a new community-based study is needed to estimate the real incidence rate of SAH in our country.

The treatment of patients with ruptured intracranial aneurysm has shifted from "delayed" to "early" approach during the past three decades. Early surgery was avoided in the past to prevent surgical difficulties arising from cerebral edema and vasospasms[2,19,20]; however, rebleeding before surgery remained a prominent cause of morbidity and mortality. In late 1980s and following reports of safety of earlier surgery,[9,27,30,31,38-40] centers started to change their protocols toward early surgery. The International Cooperative Trial data reported improved outcomes in patients who had surgical treatment within the first 3 days.[12,17,18] Thereafter, early surgery became a standard treatment protocol of most experienced neurosurgical centers especially for Hunt–Hess low-grade patients.

The highest risk of rebleeding is through the first day (4-6%), which increases over the following days, totally reaching about 28-30% after 1 month and about 50% within 6 months.[22,35,41,42] Over half of the patients with rebleeding from ruptured aneurysm die.[8] Early surgery on ruptured anterior circulation aneurysms is associated with better outcome than delayed surgery.[15] Surgery or coiling after 10 days has reported to produce poor outcomes; and procedures within 5-10 days produce less favorable outcomes than earlier treatment. Treatment during the first 3 days produces the best outcome.[11,12,14,26] Previously in our department, there was a trend for late operation of ruptured intracranial aneurysms, because swollen tight brain at surgery would not allow proper exposure of the skull base vasculature. The rate of morbidity, mortality, and rebleeding were therefore high. The establishment of the new lateral supraorbital approach along with the Helsinki anesthetic protocol[34] has permitted early surgery over the slack brains with less morbidity and mortality. We do believe that the advanced neuroanesthesia is one of the most important factors for success in the lateral supraorbital approach. Also, early surgery has significantly decreased the rebleeding rate, and it allows earlier optimization of prophylactic and therapeutic treatments for cerebral vasospasm, the major determinant of morbidity and mortality in SAH patients.[4]

The majority (about 85%) of aneurysms are found in anterior circulation.[29] Definitive prevention of rebleeding is isolation of the aneurysm from circulation, either by open surgery or endovascular techniques.[8] Endovascular approach is very expensive in our country, and access to facilities and materials is restricted. There is also limited experience and only few endovascular neurosurgeons. Due to the better familiarity of the neurosurgeons at our department with open microvascular techniques, this is our preferred approach in treating ruptured intracranial aneurysms.

Standard pterional craniotomy is a popular operative technique for clipping of anterior circulation aneurysms.[43] This approach has been used in our clinic in the past. After visiting Professor J. Hernesniemi in Helsinki Neurosurgical Department (Finland) in 2010, our team followed the lateral supraorbital approach for the majority of anterior circulation aneurysms. This approach avoids some of the complications that usually arise during the classic pterional approach, such as wasting of the temporalis muscle, injury to the frontalis branch of facial nerve, poor cosmesis related to larger craniotomy, and larger skin incision. Duration of operation and amount of blood loss also decrease significantly in this approach.[13,14,23,36,37]

Based on these benefits, early surgery has become a standard in treating most ruptured anterior circulation aneurysms, except of those in high-grade SAH patients with profound medical problems. The timing of surgery for ruptured aneurysm in posterior circulation is controversial.[11,12,31]

CONCLUSION

The establishment of early surgery for ruptured anterior circulation aneurysms through the lateral supraorbital approach along with specific anesthetic protocol has resulted in significant improvement of morbidity, mortality, and rebleeding rates at our department. In this study, we tried to share our experience about this simple and small approach, incorporated during the first 3 days of aneurysm rupture. Our center is the main referral center for cerebrovascular neurosurgery in Southern Iran and our preliminary report on the techniques encourage us to use this approach for anterior circulation aneurysm clipping. We recommend to use this approach in surgery of ruptured and, of course, unruptured aneurysms.

REFERENCES

1. Alibai EA, Khani M. Incidence of aneurysmal subarachnoid hemorrhage and analysis of factors involved in early aneurysm rebleeding. Neurosurg Q 2010;20:82-9.
2. Allcock JM, Drake CG. Ruptured intracranial aneurysms-the role of arterial spasm. J Neurosurg 1965;22:21-9.
3. Consoli A, Renieri L, Mura R, Nappini S, Ricciardi F, Pecchioli G, *et al.* Five to ten years follow-up after coiling of 241 patients with acutely ruptured aneurysms. A single centre experience. Interv Neuroradiol 2012;18:5-13.
4. Dalbayrak S, Altas M, Arslan R. The effects of timing of aneurysm surgery on vasospasm and mortality in patients with subarachnoid hemorrhage. Acta Neurol Belg 2011;111:317-20.
5. Dashti R, Laakso A, Niemela M, Porras M, Celik O, Navratil O, *et al.* Application of microscope integrated indocyanine green video-angiography during microneurosurgical treatment of intracranial aneurysms: A review. Acta Neurochir Suppl 2010;107:107-9.
6. Dashti R, Laakso A, Niemela M, Porras M, Hernesniemi J. Microscope-integrated near-infrared indocyanine green videoangiography during surgery of intracranial aneurysms: The Helsinki experience. Surg Neurol 2009;71:543-50.
7. Dashti R, Laakso A, Niemela M, Porras M, Hernesniemi J. Microscope integrated indocyanine green video-angiography in cerebrovascular surgery. Acta Neurochir Suppl 2011;109:247-50.
8. Diringer MN. Management of aneurysmal subarachnoid hemorrhage. Crit Care Med 2009;37:432-40.
9. Disney L, Weir B, Petruk K. Effect on management mortality of a deliberate policy of early operation on supratentorial aneurysms. Neurosurgery 1987;20:695-701.
10. Dorhout Mees SM, Molyneux AJ, Kerr RS, Algra A, Rinkel GJ. Timing of aneurysm treatment after subarachnoid hemorrhage: Relationship with delayed cerebral ischemia and poor outcome. Stroke 2012;43:2126-9.
11. Fogelholm R, Hernesniemi J, Vapalahti M. Impact of early surgery on outcome after aneurysmal subarachnoid hemorrhage. A population-based study. Stroke 1993;24:1649-54.

12. Haley EC Jr, Kassell NF, Torner JC. The International Cooperative Study on the Timing of Aneurysm Surgery. The North American experience. Stroke 1992;23:205-14.
13. Hernesniemi J, Ishii K, Niemela M, Smrcka M, Kivipelto L, Fujiki M, *et al.* Lateral supraorbital approach as an alternative to the classical pterional approach. Acta Neurochir Suppl 2005;94:17-21.
14. Hernesniemi J, Niemela M, Dashti R, Karatas A, Kivipelto L, Ishii K, *et al.* Principles of microneurosurgery for safe and fast surgery. Surg Technol Int 2006;15:305-10.
15. Hernesniemi J, Vapalahti M, Niskanen M, Tapaninaho A, Kari A, Luukkonen M, *et al.* One-year outcome in early aneurysm surgery: A 14 years experience. Acta Neurochir (Wien) 1993;122:1-10.
16. Ingall TJ, Whisnant JP, Wiebers DO, O'Fallon WM. Has there been a decline in subarachnoid hemorrhage mortality? Stroke 1989;20:718-24.
17. Kassell NF, Torner JC, Haley EC Jr, Jane JA, Adams HP, Kongable GL. The International Cooperative Study on the Timing of Aneurysm Surgery. Part 1: Overall management results. J Neurosurg 1990;73:18-36.
18. Kassell NF, Torner JC, Jane JA, Haley EC Jr, Adams HP. The International Cooperative Study on the Timing of Aneurysm Surgery. Part 2: Surgical results. J Neurosurg 1990;73:73:37-47.
19. Kelly PJ, Gorten RJ, Rose JE, Grossman RG, Eisenberg HM. Radionuclide cerebral angiography and the timing of aneurysm surgery. Neurosurgery 1979;5:202-7.
20. King RB, Saba MI. Forewarnings of major subarachnoid hemorrhage due to congenital berry aneurysm. N Y State J Med 1974;74:638-9.
21. Kozak N, Hayashi M. Trends in the incidence of subarachnoid hemorrhage in Akita Prefecture, Japan. J Neurosurg 2007;106:234-8.
22. Lehecka M, Hernesniemi J, Niemelä M. Distal anterior cerebral artery aneurysms. University of Helsinki; Helsinki, Finland, 2009. p. 16-7.
23. Lehecka M, Laakso A, Hernesniemi J. Helsinki Microneurosurgery Basics and Tricks. KG, Germany: DruckereiHohl GmbH and Co; 2011.
24. Lehto H, Dashti R, Karataş A, Niemelä M, Hernesniemi JA. Third ventriculostomy through the fenestrated lamina terminalis during microneurosurgical clipping of intracranial aneurysms: An alternative to conventional ventriculostomy. Neurosurgery 2009;64:430-4.
25. Linn FH, Rinkel GJ, Algra A, van Gijn J. Incidence of subarachnoid hemorrhage: Role of region, year, and rate of computed tomography: A meta-analysis. 1996;27:625-9.
26. Mahaney KB, Todd MM, Torner JC; IHAST Investigators. Variation of patient characteristics, management, and outcome with timing of surgery for aneurysmal subarachnoid hemorrhage. J Neurosurg 2011;114:1045-53.
27. Milhorat TH, Krautheim M. Results of early and delayed operations for ruptured intracranial aneurysms in two series of 100 consecutive patients. Surg Neurol 1986;26:123-8.
28. Nagy L, Ishii K, Karatas A, Shen H, Vajda J, Niemelä M, *et al.* Water dissection technique of Toth for opening neurosurgical cleavage planes. Surgical neurology 2006;65:38-41.
29. Nehls DG, Flom RA, Carter LP, Spetzler RF. Multiple intracranial aneurysms: Determining the site of rupture. J Neurosurg 1985;63:342-8.
30. Norlén G. Some aspects of the surgical treatment of intracranial aneurysms. Clin Neurosurg 1963;9:214-22.
31. Ohman J, Heiskanen O. Timing of operation for ruptured supratentorial aneurysms: A prospective randomized study. J Neurosurg 1989;70:55-60.
32. Park J, Hamm IS. Revision of Paine's technique for intraoperative ventricular puncture. Surg Neurol 2008;70:503-8.
33. Rakei SM, Alibai EA, Taghipour M, Rahmanian AK. Cerebral aneurysm in patients suffering from spontaneous subarachnoid hemorrhage in southern Iran. Iranian Red Crescent Medical Journal 2008;10: 228-32.
34. Randell T, Niemelä M, Kyttä J, Tanskanen P, Määttänen M, Karatas A, *et al.* Principles of neuroanesthesia in aneurysmal subarachnoid hemorrhage: The Helsinki experience. Surg Neurol 2006;66:382-8.
35. Risselada R, de Vries LM, Dippel DW, van Kooten F, van der Lugt A, Niessen WJ, *et al.* Incidence, treatment, and case-fatality of non-traumatic subarachnoid haemorrhage in the Netherlands. Clin Neurol Neurosurg 2011;113:483-7.
36. Romani R, Laakso A, Niemelä M, Lehecka M, Dashti R, Isarakul P, *et al.* Microsurgical principles for anterior circulation aneurysms. Acta Neurochir Suppl 2010;107:3-7.
37. Salma A, Alkandari A, Sammet S, Ammirati M. Lateral Supraorbital Approach versus pterional Approach: An Anatomic Qualitative and Quantitative Evaluation. Neurosurgery 2011;68(2 Suppl Operative):364-72.
38. Solomon RA, Onesti ST, Klebanoff L. Relationship between the timing of aneurysm surgery and the development of delayed cerebral ischemia. J Neurosurg 1991;75:56-61.
39. Suzuki J, Onuma T, Yoshimoto T. Results of early operations on cerebral aneurysms. Surg Neurol 1979;11:407-12.
40. Suzuki J, Yoshimoto T. Early operation for the ruptured intracranial aneurysm. Jpn J Surg 1973;3:149-56.
41. Winn HR, Almaani WS, Berga SL, Jane JA, Richardson AE. The long-term outcome in patients with multiple aneurysms. J Neurosurg 1983;59:642-51.
42. Winn HR, Richardson AE, Jane JA. The long-term prognosis in untreated cerebral aneurysms: I. The incidence of late hemorrhage in cerebral aneurysm: A 10-year evaluation of 364 patients. Ann Neurol 1977;1:358-70.
43. Yaşargil MG. Microneurosurgery: Operative Treatment of CNS Tumors. George Thieme Verlag Stuttgart, New York, 1995.