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PRE-OPERATIVE LUMBAR DRAINAGE VERSUS NO LUMBAR DRAINAGE IN PATIENTS UNDERGOING CLIPPING FOR RUPTURED ANEURYSMAL INTRACRANIAL BLEED

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ABSTRACT

Aim:. To compare effectiveness of Pre-operative lumbar drainage and Non- Lumbar Drainage in surgical dissection of ruptured intra-cranial aneurysm. **Materials and methods:.** A prospective, randomized, comparative study was conducted on 50 patients of aneurysmal SAH in the departmemt of neurosurgery starting from January 2020. Patients with deranged coagulation profile, meningitis contradicting placement of intra-thecal drain, infection at lumbar region and patients not giving consent were excluded. Patients were randomly assigned to two group A and group B. Patients of group A were subjected to clipping of aneurysm with Pre-operative lumbar drain placement after induction of anaesthesia and patients ofgroup B were subjected to clipping of aneurysm without lumbar drainage.

Results

- Post-operative vasospasm- The post-operative vasospasm was present in 24.0% of the cases of lumbar drain group and 52.0% of the cases without lumbar drain group which was statistically significant.
- Post-operative early infarct -Post-operative early infarct was present in 8.0% of the cases in lumbar drain group and 32.0% of the cases without lumbar drain group which was statistically significant.
- Post-operative late infarct- The post-operative late infarct was present in 4.0% of the lumbar rain group and 24.0% of the patients without lumbar drain group which was statistically significant
- Post-operative ICU stay- Post-operative ICU stay was less than or equal to 7 days in 84.0% of the cases in lumbar drain group and 56.0% of the without lumbar drain group which was statistically significant
- On discharge motor deficit- On discharge motor deficit was present in 20.0% of the cases in lumbar drain group and 24.0% of the cases in without lumbar drain group which was not statistically significant

Conclusions: This study was undertaken mainly to study the efficacy of lumbar drainage in management of ruptured aneurysm with SAH. This study had shown that, the lumbar drain was useful in preventing the vasospasm, early and late infarct. The number of days of stay in ICU was also lower in lumbar drain group than the control group. In addition lumbar drain does provide help to surgeon in surgical dissection of sylvian fissure as well as dissection around aneurysm

KEYWORDS : SAH, DSA, IVH, CSF, ICP, AVM, HMG, IEL, ICA, FLAIR, GRE, SWI, CTA, MRA, ISAT, GOS, NIHSS, LUMAS

INTRODUCTION

Intracranial aneurysms (IAs) are localized dilatations or ballooning of the arteries in the brain due to weakness of the arterial wall. Their rupture and associated intra-cranial haemorrhage can lead to serious morbidity and mortality. Most cerebral aneurysms are acquired lesions, with increased incidence in patients with certain risk factors such as advanced age, hypertension, smoking, alcohol abuse, cocaine abuse and atherosclerosis. There is also a strong genetic element with significantly increased incidence in patients with a strong family history of aneurysms (in other words, more than one family member affected). Certain genetic conditions are associated with higher prevalence like autosomal dominant polycystic kidney disease, Ehlers-Dahlos syndrome, fibromuscular dysplasia, tuberous sclerosis, arteriovenous malformations (AVM), and coarctation of the aorta.[1]

They can be classified according to size and shape. According to size they can be small (<5 mm), medium (5 to 10 mm), large (11 – 25mm) and giant (>25mm). According to shape they can be saccular (berry) aneurysms, fusiform aneurysm and dissecting aneurysm. Saccular aneurysms are associated with deficient tunica media and internal elastic lamina. However, fusiform (circumferential) and dissecting aneurysms are present in a small percentage of cases. The majority of cerebral aneurysms are asymptomatic and may be found incidentally on imaging or upon autopsy. Approximately 85% of aneurysms are located in the anterior circulation, predominately at junctions or bifurcations along the circle of Willis.

Intracranial aneurysms mainly present with their rupture causing subarachnoid haemorrhage (SAH), intracerebral haemorrhage (ICH) or intraventricular haemorrhage (IVH). The average annual incidence of aneurysmal SAH is estimated to be approximately 6-7 per 100,000 persons[2] and the estimated prevalence of unruptured intracranial aneurysmal is 0.2%-10% of the general population.[3] Aneurysmal subarachnoid haemorrhage (SAH) is a life-threatening medical emergency requiring immediate intervention as approximately 12% of the patients die before receiving medical support, 33% die within 48 h and 50% within 30 days of SAH (ictus). Most of the survivors suffer from permanent disability and dependency.[4]

Intra-cranial aneurysms are mainly diagnosed on the basis of CT angiography or DSA brain. The goal of intracranial aneurysm surgery is to obliterate the aneurysm while flow in the vessels associated with the aneurysm is maintained. Microsurgical clipping and endovascular coiling are the two most commonly used treatment modalities for ruptured cerebral aneurysm. Aneurysms are diverse and therefore the surgical approach to an aneurysm depends in large part on the specific aneurysm to be treated, including its location and relationship to the skull base and surrounding structures, its morphology (e.g. size, neck dome ratio), the afferent and efferent vessels and collaterals, and besides this on patient's clinical condition and consent.

There are Primarily two approaches for treatment of intra-cranial aneurysm

1. Microvascular clipping of aneurysm
2. Endovascular coiling of aneurysm

Dandy started clipping aneurysm in 1937[5] since then microsurgical clipping has remained the gold standard in treatment for intra-cranial aneurysm.

In 1991, Guido Guglielmi was the first to describe the technique of emboling aneurysm using an endo-vascular approach with electrolyticaly detachable platinum coils, termed Guglielmi detachable coils.[6]

Indications for aneurysm coiling are-

1. Posterior circulation aneurysm
2. Multiple aneurysm
3. Paraclinoid aneurysm
4. Giant aneurysm, fusiform, dissecting, mycotic, pseudoaneurysm

5. Blood blister like aneurysm

Limitations of endovascular treatment are
1. Renal failure
2. Non availability of DSA facility
3. High cost of material
4. Aneurysm with large parenchymal clots may require surgical evacuation and clipping done in the same sitting.

An aneurysm clipped through a craniotomy, is a surgical procedure in which the brain and the blood vessels are accessed through an opening in the skull. The aneurysm is identified,dissected from the surrounding brain tissue and vessels and then clipped. In the ideal clipping, normal blood vessel anatomy is physically restored by excluding the aneurysm sac from the cerebral circulation. Adequate brain relaxation is necessary for exposure of aneurysms of the circle of Willis. In the setting of recent subarachnoid haemorrhage (SAH), hyperventilation and diuresis are often not sufficient to achieve the atraumatic brain retraction necessary to reach the basal cisterns. Surgeons have, therefore, advocated either preoperative ventriculostomy, intraoperative ventriculostomy, or spinal drainage to remove cerebrospinalfluid (CSF) and provide additional relaxation.[7,8,9,10]

There are several advantages of lumbar drainage of CSF over ventriculostomy to achieve adequate brain relaxation. There is less incidence of aneurysm rebleeding in patients undergoing lumbar drainage then ventriculostomy because of gradual reduction of ICP in lumbar drainage.[11,12,13,14,15,16] It avoids the need for the transcortical pass of ventricular catheter and is associated with less incidence of ventriculitis and meningitis.[17,18,19] Spinal drainage also allows for a slightly fuller ventricles and cisterns than ventricular drainage which facilitates arachnoidal dissection and minimizes epidural bleeding.

Spinal drainage provides access to a larger reservoir of CSF then ventriculostomy (130 cc versus 20 cc) permitting a greater degree of relaxation if required. When placed immediately prior to patient positioning, CSF drainage can be minimized during the early phases of surgery ,preventing epidural stripping until tenting sutures are placed, besides this it facilitates dissection of the sylvian fissure. When brain retraction is required large volume of CSF can be drained to achieve atraumatic brain retraction.[20,21] Incidence of vasospasm is also less with lumbar drainage as compared to ventricular drainage because lumbar drainage helps in maximal drainage of blood present in basal cisterns.Nevertheless, the loss of too much cerebrospinal fluid(CSF) precipitating mild to severe complications are a possibility associated with these manoeuvres. Mild and self-limiting complications of lumbar drainage include the onset of postural headaches, nausea, vomiting, persistent CSF leaks requiring epidural patch, decreased vision, abducent nerve paresis.

There have been very few previous studies done by researchers, assessing the role of pre-operative lumbar drainage in achieving brain relaxation and thus aid in surgical ease of many intra-cranial surgeries. One such study was done by Ashwin Viswanathan and collegues in assessing the role of lumbar drainage in occipital lobe arteriovenous malformations. It was found that Lumbar drainage of CSF was an effective and safe technique and an alternative to ventriculostomy placement in accomplishing Brain relaxation and minimal retraction in occipital lobe approaches in children.[22]

Study done by E.sander conolly and collegues have found that Brain relaxation can be safely and effectively obtained using intra-operative spinal drains during early aneurysm surgery. Spinal drainage has been shown to be associated with reduced rate of re-bleeding as compared to ventriculostomy.[23]

There are no studies in literature which suggests that whether use of pre-operative lumbar drainage helps in surgical dissection of aneurysm and provides surgical ease in clipping of aneurysm thus reducing temporary clipping time and overall surgery time in microsurgical clipping of aneurysm.

Keeping in view of the above we have planned a randomized control study on lumbar drainage in patients undergoing clipping after rupture of intra-cranial aneurysm.

MATERIAL AND METHODS

This prospective randomized study was conducted on 50 patients of Ruptured intracranial aneurysm undergoing clipping in the Department of Neurosurgery, PGIMS ROHTAK, starting from January 2020.Informed consent for study was taken from each patient in their local language.

Diagnosis was made on the basis of clinical history and examination, radiological investigation like Ncct brain and CT angiography brain.

Blood investigations like Heamoglobin, coagulation profile, renal function tests, serum electrolytes were noted for all patients. Study was done after taking clearance from ethical committee of the institution.

Patients were randomly assigned to two groups A and B using online random number generator. (http://stattrek.com/statistics/random-number-generator.aspx) which is commonly used for such research purposes. Patients of group A were subjected to clipping of aneurysm with Pre-operative lumbar drain placement after induction of anaesthesia(study group) and patients of group B were subjected to clipping of aneurysm without lumbar drainage.(control group)

Inclusion Criteria

- Patients of age group 15-65 yrs with ruptured aneurysmal intracranial haemorrhage undergoing clipping.

Exclusion Criteria

1. Deranged coagulation profile.
2. Meningitis contradicting placement of intrathecal drains.
3. Infection at the lumbar region.
4. Patients not giving consent.

All patients were assigned a WFNS GRADE at the time of admission according to neurological parameters.The patients were also be assigned a fisher's grade based upon thickness of subarachnoid clot on CT scan of Head.

WFNS Grading: -

WFNS GRADE	GCS Score	Motor Deficit.
Grade 1	15	Absent
Grade 2	14-13	Absent
Grade 3	14-13	Present
Grade 4	12-7	Present or Absent
Grade 5	6-3	Present or Absent

Fisher CT Grading Scale

Fisher Grade
1. No subarachnoid blood detected
2. Diffuse or vertical layers<1 mm thick
3. Localised clot or vertical layers >1 or =1 thick
4. Intracerebral or Intraventricular clot with diffuse or no SAH

Vasospasm was diagnosed using following criteria.
1. Deficits such as confusion, disorientation, drowsiness or focal motor deficits during post hemorrhage days 4-14.
2. Negative findings on CT scan obtained to rule out other causes of neurological deterioration such as haemorrhage, cerebral edema or hydrocephalus.
3. No other identifiable cause of neurological deterioration such as hyponatremia(Na<130), hypoxia, drug toxicity, infection or seizures.

Cerebral infarction caused by vasospasm was diagnosed if either a delayed ischemic deficit became sustained beyond the risk period of cerebral vasospasm or if imaging studies revealed a region of cerebral infarction in a vascular territory consistent with the patient's vasospasm.

Surgical technique

In all patients randomized under the lumbar CSF drainage group closed system lumbar CSF Drain(Surgiwear Lumbar drain) is Typically placed in operating room after of induction of anaesthesia and is clamped. Perioperative antibiotics are given 30 minutes prior to puncture, and after placement of the drain the patient is immediately placed supine, and positioned for craniotomy. Drain is closed till the craniotomy. After craniotomy drain is opened and CSF is drained according to tightness of Brain. Clipping of aneurysm is done as per site of aneurysm. If required Intermittent temporary clip were applied before dissection of neck. Permanent clip applied after neck dissection. Lumbar drain was removed 5 days after surgery or till the time CSF becomes clear.

Evaluation Parameters:

A. Intra-operative parameters.

This will include:

1. Time taken for dissection of sylvian fissure.
2. Time taken for dissection and separation of intracranial aneurysm
3. Temporary clipping time
4. Total operative time.
5. Need for ventricular drainage intra-operatively in case of non-lumbar drainage group.
6. Comparison of intra-operative rupture in two groups.
7. Time for clipping in case of aneurysm rupture in two groups.

B. Post-operative parameters:

1. Post-operative complication including vasospasm
2. Post-op NCCT brain (Fisher grade)
3. Length of hospital stay
4. Post-spinal headache
5. Infection
6. Glasgow outcome score at 1 and 3-months follow-up.

Statistical Analysis

Statistical analysis was performed using an unpaired t-test for parametric variables. Categorical variables were analyzed in contingency tables using the Fisher exact test. Results with $p < 0.05$ were considered as significant.

RESULTS

Table 1. Distribution of the study groups according to age group

Age group	Lumbar drain groupn (%)	Without lumbar drain group n (%)
31 – 40 years	1 (4.0)	0
51 – 60 years	5 (20.0)	6 (24.0)
61 – 70 years	11 (44.0)	13 (52.0)
> 70 years	8 (32.0)	6 (24.0)
Total	25 (100)	25 (100)

χ^2 value= 1.543 df=3 p value, sig=0.672, NS

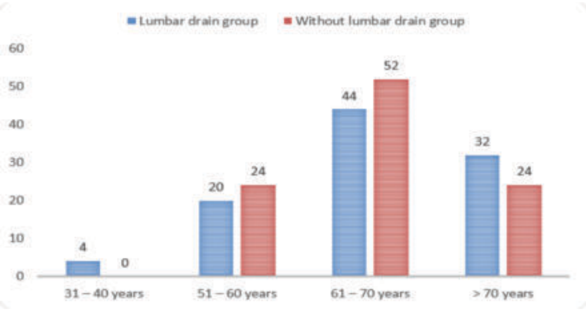

Chart 1. Distribution of the study groups according to age group

This study had shown that about 44.0% of the cases in lumbar drain group and 52.0% of the case in without lumbar drain group were 61 – 70 years of age. This difference in age was not statistically significant between the lumbar drain and without lumbar drain group.

Table 2. Distribution of the study groups according to Sex

Sex	Lumbar drain group n (%)	Without lumbar drain group n (%)
Male	11 (44.0)	11 (44.0)
Female	14 (56.0)	14 (56.0)
Total	25 (100)	25 (100)

χ^2 value= 0.000 df=1 p value, sig=1.000, NS

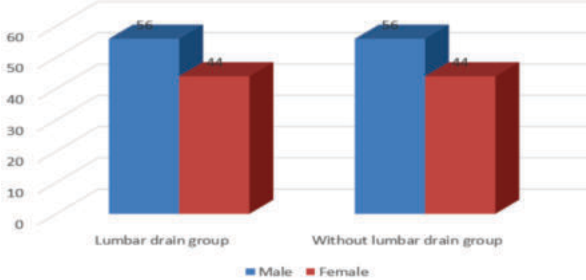

Chart 2. Distribution of the study groups according to Sex

In this study, about 44.0% of the cases were males and 56.0% of the cases were females in both lumbar drain and without lumbar drain groups. This difference in sex was not statistically significant.

Table 3. Distribution of the study groups according to location of aneurysm

Location of aneurysm	Lumbar drain group n (%)	Without lumbar drain group n (%)
ACoA	7 (28.0)	4 (16.0)
BA - SCA	1 (4.0)	3 (12.0)
BA tip	3 (12.0)	2 (8.0)
Distal ACA	2 (8.0)	1 (4.0)
ICA	7 (28.0)	6 (24.0)
MCA	5 (20.0)	5 (20.0)
P COM	0	4 (16.0)
Total	25 (100)	25 (100)

χ^2 value= 6.428 df=6 p value, sig=0.377, NS

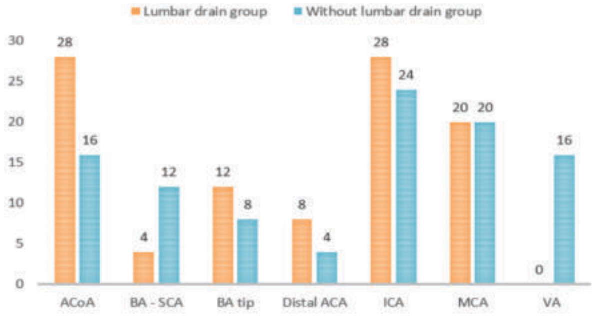

Chart 3. Distribution of the study groups according to location of aneurysm

About 28.0% of the cases in lumbar drain group had aneurysm in anterior communication artery and internal carotid artery had aneurysm. The without lumbar drain group, 24% of the cases had aneurysm in internal carotid artery. This difference was not statistically significant between the two groups.

Table 4. Distribution of the study groups according to WFNS on admission

WFNS on admission	Lumbar drain group n (%)	Without lumbar drain group n (%)
Grade 2	1 (4.0)	0
Grade 3	7 (28.0)	11 (44.0)
Grade 4	13 (52.0)	11 (44.0)
Grade 5	4 (16.0)	3 (12.0)
Total	25 (100)	25 (100)

χ^2 value= 2.198 df=3 p value, sig=0.532, NS

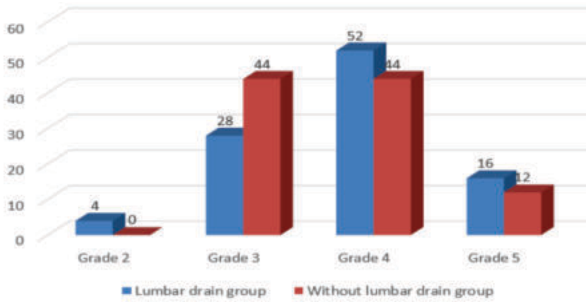

Chart 4. Distribution of the study groups according to WFNS on admission

About 52.0% of the cases in lumbar drain group and 44.0% of the cases in without lumbar drain group had grade 4 WFNS. This difference was not statistically significant between the two groups.

Table 5. Distribution of the study groups according to pre-operative Sub-arachnoid, parenchymal and ventricular bleed

Pre-operative parenchymal entricular bleed	Lumbar drain group n (%)	Without lumbar drain group n (%)
Ventricular	5 (20.0)	2 (8.0)
Subarachnoid bleed	12 (48.0)	13 (52.0)

Ventricular +subarachnoid	8 (32.0)	10 (40.0)
Total	25 (100)	25 (100)

χ^2 value= 1.548 df=2 p value, sig=0.461, NS

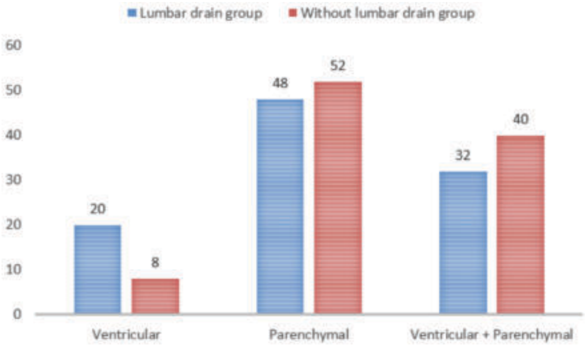

Chart 5. Distribution of the study groups according to pre-operative subarachnoid and ventricular bleed

About 48.0% of the cases in lumbar drain group and 52.0% in the without lumbar drain group had Sub-arachnoid bleeding. This difference was not statistically significant between the two groups.

Table 6. Distribution of the study groups according to pre-operative Fischer's grade

Pre-operative Fischer's grade	Lumbar drain group n (%)	Without lumbar drain group n (%)
Grade 1	6 (24.0)	4 (16.0)
Grade 2	14 (56.0)	13 (52.0)
Grade 3	5 (20.0)	8 (32.0)
Total	25 (100)	25 (100)

χ^2 value= 1.129 df=2 p value, sig=0.569, NS

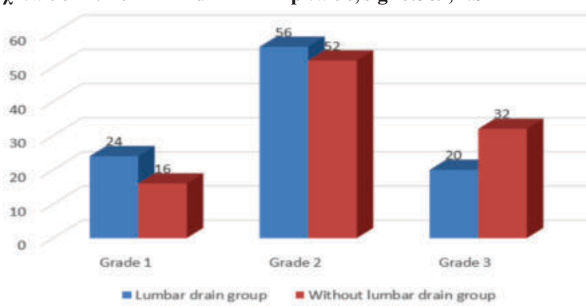

Chart 6. Distribution of the study groups according to pre-operative Fischer's grade

About 56.0% of the cases in lumbar drain group and 52.0% in the without lumbar drain group had Fischer's grade 2 during pre-operative period. This difference was not statistically significant between the two groups.

Table 7. Distribution of the study groups according to pre-operative hydrocephalus

Pre-operative Hydrocephalus	Lumbar drain group n (%)	Without lumbar drain group n (%)
Yes	14 (56.0)	11 (44.0)
No	11 (44.0)	14 (56.0)
Total	25 (100)	25 (100)

χ^2 value= 0.72 df=1 p value, sig=0.396, NS

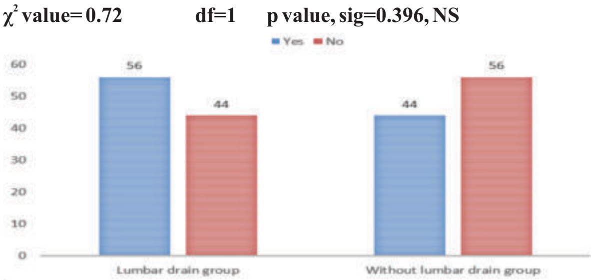

Chart 7. Distribution of the study groups according to pre-operative hydrocephalus

About 56.0% of the cases had lumbar drain group and 44.0% in the without lumbar drain group had hydrocephalus. This difference was not statistically significant between the two groups.

Table 8. Distribution of the study groups according to pre-operative aneurysm size

Pre-operative aneurysm size	Lumbar drain group n (%)	Without lumbar drain group n (%)
≤ 7 mm	14 (56.0)	14 (56.0)
8 – 14 mm	11 (44.0)	11 (44.0)
Total	25 (100)	25 (100)

χ^2 value= 0.000 df=1 p value, sig=1.000, NS

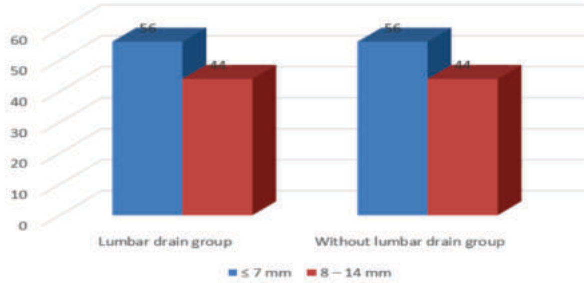

Chart 8. Distribution of the study groups according to pre-operative aneurysm size

About 56.0% of the cases in lumbar drain group and 56.0% in without lumbar drain group had aneurysm of less than 7 mm. This difference was not statistically significant between the two groups.

Table 9. Distribution of the study groups according to pre-operative time since bleed

Pre-operative time since bleed	Lumbar drain group n (%)	Without lumbar drain group n (%)
< 7 days	14 (56.0)	13 (52.0)
7 – 14 days	11 (44.0)	12 (48.0)
Total	25 (100)	25 (100)

χ^2 value= 0.081 df=1 p value, sig=0.777, NS

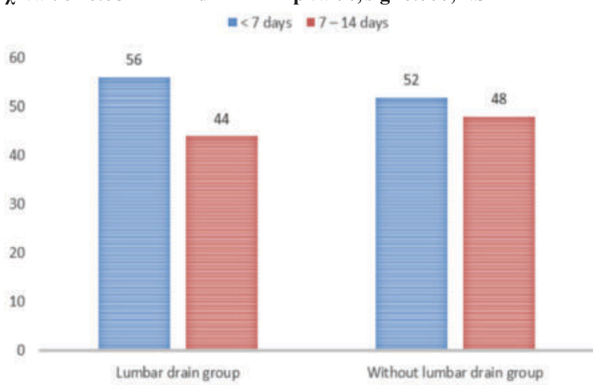

Chart 9. Distribution of the study groups according to pre-operative time since bleed

The pre – operative bleed was present in 56.0% of the lumbar drain group and 52.0% of the without lumbar drain group. This difference was not statistically significant between the two groups.

Table 10. Distribution of the study groups according to intra operative rupture

Intra operative rupture	Lumbar drain group n (%)	Without lumbar drain group n (%)
Yes	6 (24.0)	13 (52.0)
No	19 (76.0)	12 (48.0)
Total	25 (100)	25 (100)

χ^2 value= 4.16 df=1 p value, sig=0.041, Sig

The intra operative rupture was present in 24.0% of the lumbar drain group and 52.0% of the without lumbar drain group. This difference was a statistically significant between the two groups.

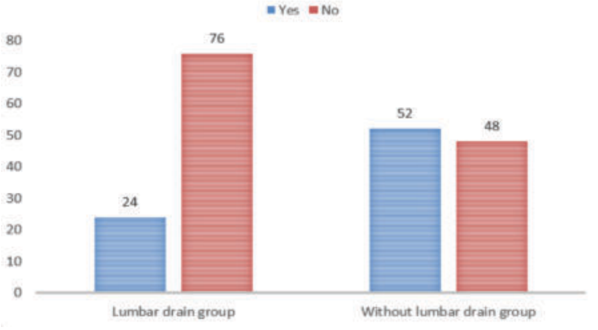

Chart 10. Distribution of the study groups according to intra operative rupture

Table 11. Distribution of the study groups according to intra operative temporary clipping

Intra operative temporal clipping	Lumbar drain group n (%)	Without lumbar drain group n (%)
Yes	16 (64.0)	21 (84.0)
No	9 (36.0)	4 (16.0)
Total	25 (100)	25 (100)

χ^2 value= 2.599 df=1 p value, sig=0.107, NS

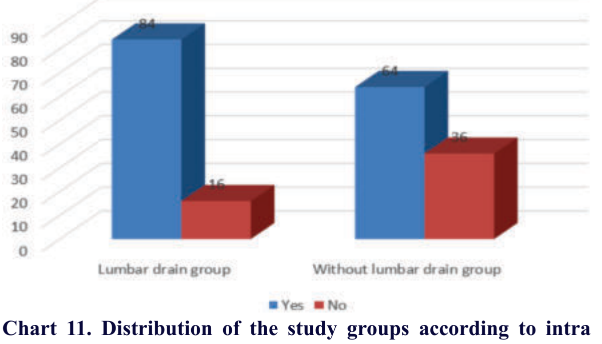

Chart 11. Distribution of the study groups according to intra operative temporary clipping

Intra operative temporal clipping was done in 64.0% of the lumbar drain group and 84.0% of the without lumbar drain group. This difference was not statistically significant between the two groups.

Table 12. Distribution of the study groups according to post-operative vasospasm

Post-operative vasospasm	Lumbar drain group n (%)	Without lumbar drain group n (%)
Yes	6 (24.0)	13 (52.0)
No	19 (76.0)	12 (48.0)
Total	25 (100)	25 (100)

χ^2 value= 4.16 df=1 p value, sig=0.041, Sig

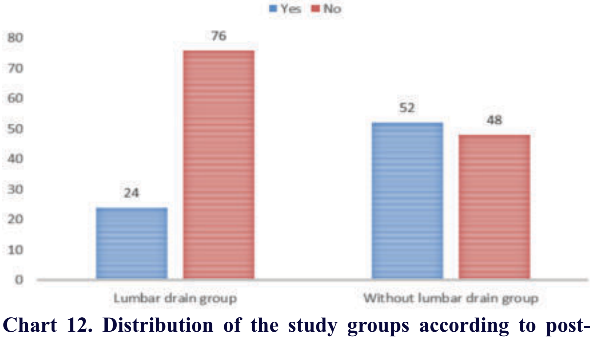

Chart 12. Distribution of the study groups according to post-operative vasospasm

Post-operative vasospasm was present in 24.0% of the lumbar drain group and 52.0% of the without lumbar drain groups. This difference was statistically significant between the two groups.

Table 13. Distribution of the study groups according to post-operative early infarct

Post-operative early infarct	Lumbar drain group n (%)	Without lumbar drain group n (%)
Yes	2 (8.0)	8 (32.0)
No	23 (92.0)	17 (68.0)
Total	25 (100)	25 (100)

χ^2 value= 4.5 df=1 p value, sig=0.034, Sig

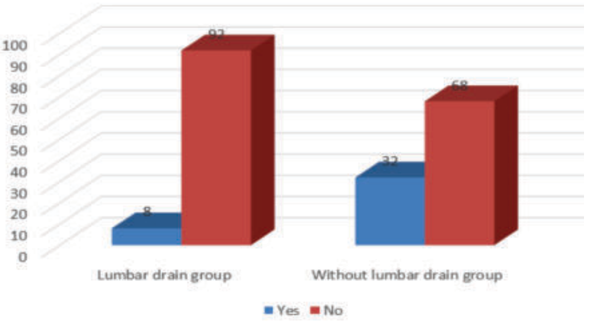

Chart 13. Distribution of the study groups according to post-operative early infarct

Post-operativeearly infarct was present in 8.0% of the lumbar drain group and 32.0% of the without lumbar drain group. This difference was statistically significant between lumbar drain group and without lumbar drain groups.

Table 14. Distribution of the study groups according to post-operative late infarct

Post-operative late infarct	Lumbar drain group n (%)	Without lumbar drain group n (%)
Yes	1 (4.0)	6 (24.0)
No	24 (96.0)	19 (76.0)
Total	25 (100)	25 (100)

χ^2 value= 4.153 df=1 p value, sig=0.042, Sig

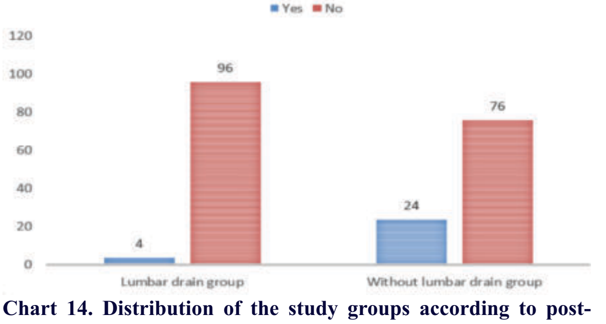

Chart 14. Distribution of the study groups according to post-operative late infarct

Post – operative late infarct was present in 4.0% of the lumbar drain group and 24.0% of the without lumbar drain group. This difference was statistically significant between lumbar drain and without lumbar drain groups.

Table 15. Distribution of the study groups according to post-operative CSF diversion

Post-operative CSF diversion	Lumbar drain group n (%)	Without lumbar drain group n (%)
Yes	4 (16.0)	9 (36.0)
No	21 (84.0)	16 (64.0)
Total	25 (100)	25 (100)

χ^2 value= 2.599 df=1 p value, sig=0.107, NS

The post-operative CSF diversion was present in 16.0% of the lumbar drain group and 36.0% of the without lumbar drain groups. This difference was not statistically significant between the two groups.

Table 16. Distribution of the study groups according to post-operative re exploration/ decompression

Post-operative re exploration/ ecompression	Lumbar drain group n (%)	Without lumbar drain group n (%)
Yes	1 (4.0)	5 (20.0)

No	24 (96.0)	20 (80.0)
Total	25 (100)	25 (100)

χ^2 value= 3.03 df=1 p value, sig=0.082, NS

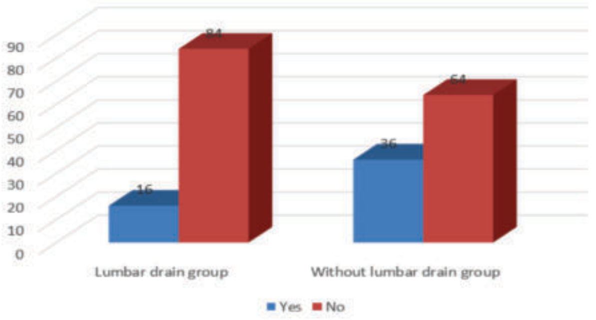

Chart 15. Distribution of the study groups according to post-operative CSF diversion

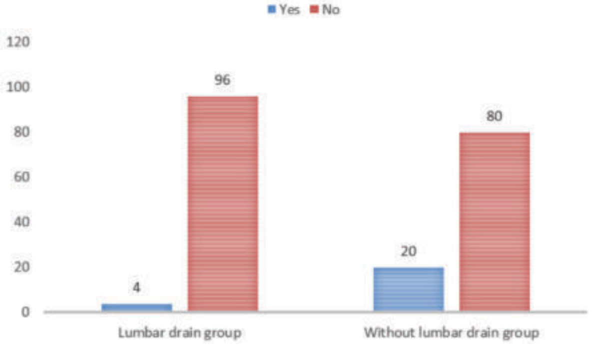

Chart 16. Distribution of the study groups according to post-operative re exploration/ decompression

About 4.0% of the lumbar drain group and 20.0% if the without lumbar drain group had post-operative re exploration/ decompression. This difference was not statistically significant between lumbar drain group and without lumbar drain groups.

Table 17. Distribution of the study groups according to post-operative ventilatory support

Post-operative ventilatory support	Lumbar drain group n (%)	Without lumbar drain group n (%)
Yes	6 (24.0)	6 (24.0)
No	19 (76.0)	19 (76.0)
Total	25 (100)	25 (100)

χ^2 value= 0.000 df=1 p value, sig=1.000, NS

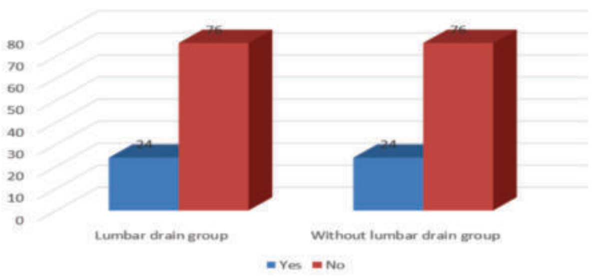

Chart 17. Distribution of the study groups according to post-operative ventilatory support

Post-operative ventilatory support was given to 24.0% of the lumbar drain group and 24.0% of the without lumbar drain group patients. This difference was not statistically significant between the two groups.

Table 18. Distribution of the study groups according to post-operative ICU stay

Post-operative ICU stay	Lumbar drain group n (%)	Without lumbar drain group n (%)
≤ 7 days	21 (84.0)	14 (56.0)
> 7 days	4 (16.0)	11 (44.0)
Total	25 (100)	25 (100)

χ^2 value= 4.667 df=1 p value, sig=0.031, Sig

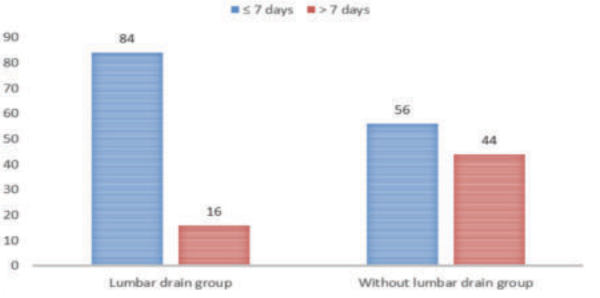

Chart 18. Distribution of the study groups according to post-operative ICU stay

About 84.0% of the lumbar drain group patients and 56.0% of the patients without lumbar drain group patients stayed in ICU for less than or equal to 7 days. This difference was statistically significant between the two groups.

Table 19. Distribution of the study groups according to post-operative WFNS

Post-operative WFNS	Lumbar drain groupn (%)	Without lumbar drain group n (%)
Grade 1	15 (60.0)	13 (52.0)
Grade 2	10 (40.0)	12 (48.0)
Total	25 (100)	25 (100)

χ^2 value= 0.325 df=1 p value, sig=0.569, NS

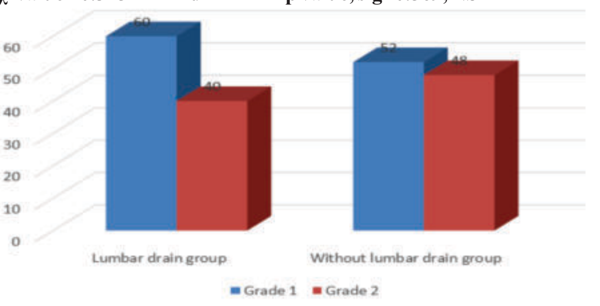

Chart 19. Distribution of the study groups according to post-operative WFNS

About 60.0% of the lumbar drain group of patients and 52.0% of the cases without lumbar drain had post-operative grade 1. This difference was not statistically significant between the two groups.

Table 20. Distribution of the study groups according to on discharge motor deficit

On discharge motor deficit	Lumbar drain group n (%)	Without lumbar drain group n (%)
Yes	5 (20.0)	6 (24.0)
No	20 (40.0)	19 (76.0)
Total	25 (100)	25 (100)

χ^2 value= 0.117 df=1 p value, sig=0.733, NS

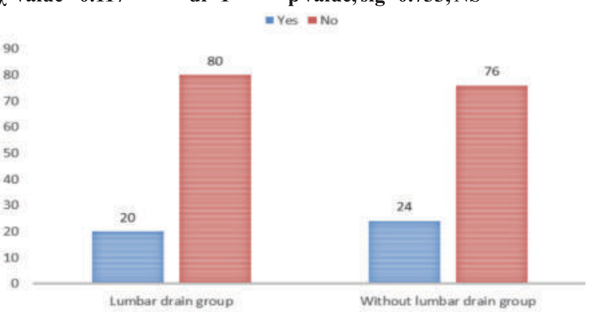

Chart 20. Distribution of the study groups according to on discharge motor deficit

About 20.0% of the patients in lumbar drain group and 24.0% of the cases in without lumbar drain group had on discharge motor deficit. This difference was not statistically significant between the two groups.

Table 21. Distribution of the study groups according to on discharge sensory deficit

On discharge sensory deficit	Lumbar drain groupn (%)	Without lumbar drain group n (%)
Yes	3 (12.0)	4 (16.0)
No	22 (88.0)	21 (84.0)
Total	25 (100)	25 (100)

χ^2 value= 0.166 df=1 p value, sig=0.684, NS

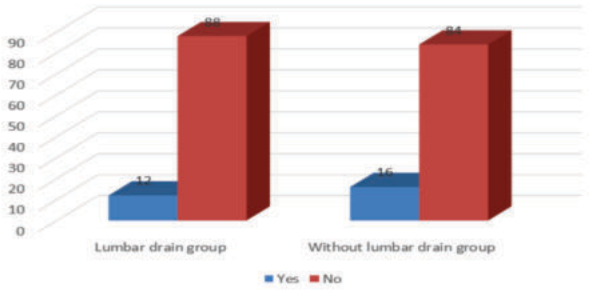

Chart 21. Distribution of the study groups according to on discharge sensory deficit

About 12.0% of the cases in lumbar drain group and 16.0% of the patients in without lumbar drain group had on discharge sensory deficit. This difference was not statistically significant between the two groups.

Table 22. Distribution of the study groups according to on discharge neurological impairment

On discharge neurological mpairment	Lumbar drain group n (%)	Without lumbar drain group n (%)
Yes	3 (12.0)	3 (12.0)
No	22 (88.0)	22 (88.0)
Total	25 (100)	25 (100)

χ^2 value= 0.000 df=1 p value, sig=1.000, NS

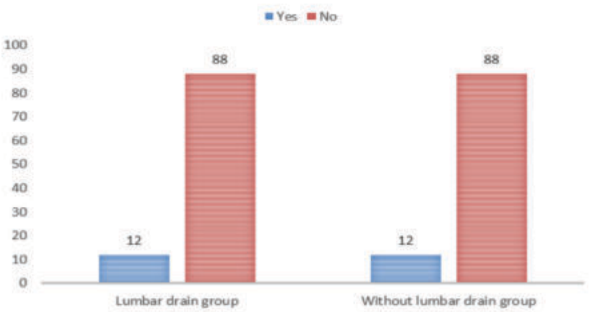

Chart 22. Distribution of the study groups according to on discharge neurological impairment

About 12.0% of the lumbar drain group patients and 12.0% of the cases in without lumbar drain group had on discharge neurological impairment. This difference was not statistically significant between the two groups.

Table 23. Distribution of the study groups according to time taken for dissection of sylvian fissure

Time taken for dissection of sylvian fissure (in mins)	Lumbar drain group	Without lumbar drain group	T value	P value, Sig
Mean ± SD	22.16 ± 3.17	33.04 ± 2.68	13.093	0.000, Sig

Mean time taken for dissection of sylvian fissure in lumbar drain group was 22.16 minutes and 33.04 minutes in patients without lumbar drain group. This difference was statistically significant between the two groups.

Table 24. Distribution of the study groups according to time taken for dissection around aneurysm

Time taken for dissection around aneurysm(in mins)	Lumbar drain group	Without lumbar drain group	T value	P value, Sig
Mean ± SD	29.64 ± 3.17	38.92 ± 3.65	9.896	0.000, Sig

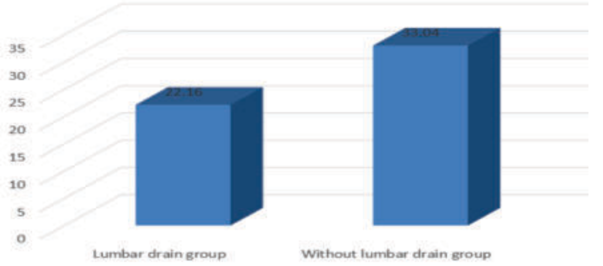

Chart 23. Distribution of the study groups according to time taken for dissection of sylvian fissure

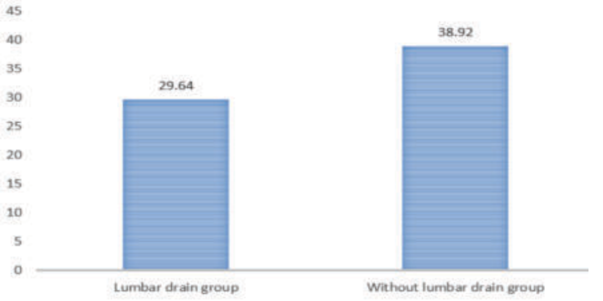

Chart 24. Distribution of the study groups according to time taken for dissection around aneurysm

Mean time taken for dissection around aneurysm was 29.64 minutes in lumbar drain group and 39.92 minutes in without lumbar drain group. This difference was statistically significant between the two groups.

Table 25. Distribution of the study groups according to total temporary clipping time

Total temporary clipping time (in mins)	Lumbar drain group	Without lumbar drain group	T value	P value, Sig
Mean ± SD	5.72 ± 2.7	11.6 ± 3.85	6.215	0.000, Sig

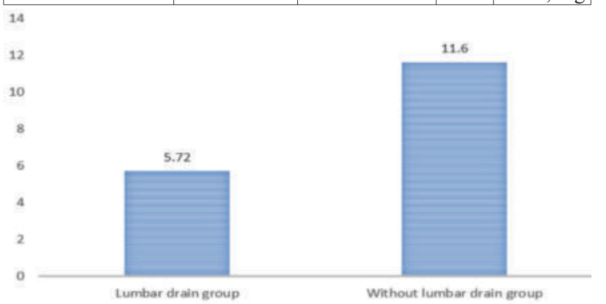

Chart 25. Distribution of the study groups according to total temporary clipping time

The mean temporary clipping time in lumbar drain group was 5.72 minutes and 11.6 in non-lumbar drain group. This difference was statistically significant between the two groups.

Table 26. Distribution of the study groups according to total time of surgery

Total time of surgery	Lumbar drain group	Without lumbar drain group	T value	P value, Sig
Mean ± SD	87.5 ± 2.7	103.5 ± 5.2	18.55	0.000, Sig

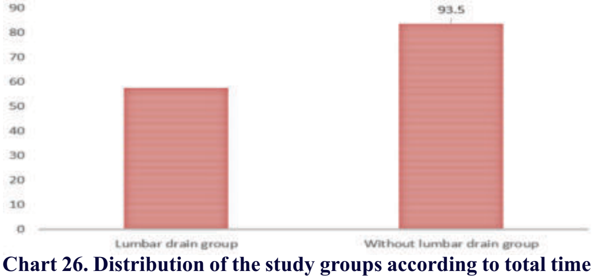

Chart 26. Distribution of the study groups according to total time of surgery

The total time of surgery in lumbar drain group was 87.5 minutes and 103.5 minutes in non-lumbar drain group. This difference was statistically significant between the two groups.

Table 27. Distribution of the study groups according to need for ventricular drainage(intra-operative)

Need for ventricular drainage	Lumbar drain group n (%)	Without lumbar drain group n (%)
Yes	0 (0.0)	6 (24.0)
No	25 (100.0)	19 (76.0)
Total	25 (100)	25 (100)

χ^2 value= 4.153 df=1 p value, sig=0.042, Sig

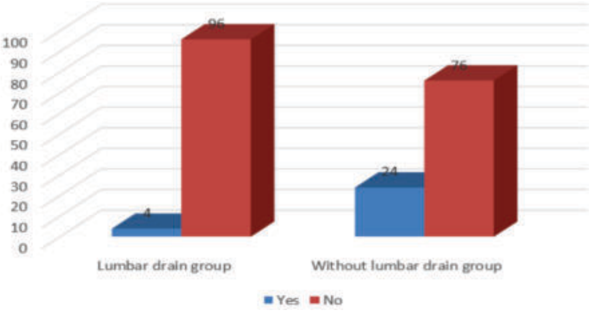

Chart 27. Distribution of the study groups according to need for ventricular drainage

None of the patients in lumbar drain group and 24.0% in non-lumbar drain group needed intra-operative ventricular drainage in this study. This difference in need for ventricular drainage was statistically significant between the two groups.

Table 28. Distribution of the study groups according to time taken for clipping after intra operative rupture

Time taken for clippingafter intra operative rupture (in mins)	Lumbar drain group	Without lumbar drain group	T value	P value, Sig
Mean ± SD	16.88 ± 3.1	21.0 ± 2.1	3.639	0.002, Sig

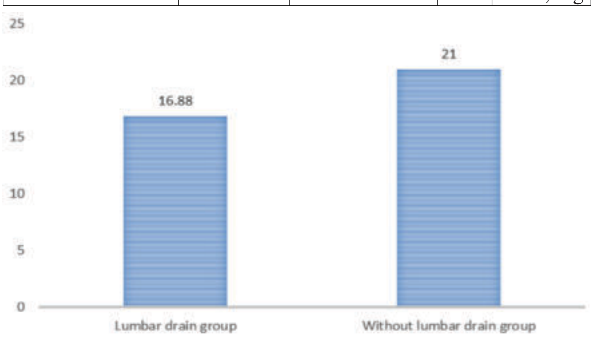

Chart 28. Distribution of the study groups according to time taken for clipping after intra operative rupture

The mean time of clipping of aneurysms which had intra operative rupture was 16.88 minutes in the lumbar drain group and 21 minutes in non-lumbar drain group. This difference was statistically significant.

DISCUSSION

Intracranial aneurysms (IAs) are localized dilatations or ballooning of the arteries in the brain due to weakness of the arterial wall . Their rupture and associated intra cranial haemorrhage which can lead to serious morbidity and mortality. Microsurgical clipping and Endovascular coiling are the two main modalities for obliteration of intra-cranial aneurysms.

In our centre all patients were treated by micro-surgical clipping of aneurysm where indicated as endovascular facility is not available in our set-up.

Microsurgical clipping of an aneurysm is a surgical procedure in which the brain and the blood vessels are accessed through craniotomy.. The aneurysm is identified, dissected from the surrounding brain tissue and vessels and then clipped. In the ideal clipping, normal blood vessel anatomy is physically restored by excluding the aneurysm sac from the cerebral circulation.

Adequate brain relaxation is necessary for exposure of aneurysms of the circle of Willis. Brain relaxation describes the relationship between the volume of the intracranial contents and the capacity of the intracranial space when the cranium and dura are opened by the neurosurgeon. Brain relaxation is adequate if the volume of intracranial contents is equal to or less than the capacity of the intracranial space. On the contrary, the brain relaxation is inadequate if the volume of intracranial contents surpasses the capacity of the intracranial space. The modern concept of brain relaxation should be defined as an ideal volume of the intracranial contents in relationship to the capacity of the intracranial space that provides optimal operating conditions during open intracranial surgery and a beneficial patient outcome afterwards.

Optimal brain relaxation improves surgeon's operating conditions, results in easier access to target lesion, and reduces iatrogenic injuries due to brain retraction.

In relaxed brain extradural drilling of bone, brain retraction and cisternal opening becomes easier.

There are various methods of achieving intra-operative brain relaxation during intra-cranial aneurysm surgery.

1. Hyperventilation
2. Diuresis
3. Hyperosmolar agents like mannitol.
4. CSF diversion procedures like ventriculostomy and lumbar drainage.

In the setting of recent subarachnoid haemorrhage (SAH), hyperventilation and diuresis are often not sufficient to achieve the atraumatic brain retraction necessary to reach the basal cisterns.

The principle mechanism of hyperosmotic agents in brain relaxation is the induction of water shift from brain tissues to intravascular space and the subsequent brain-bulk reduction. However, administration of mannitol can be associated with severe adverse effects such as hypovolemia, rebound ICP elevation, hyperkalemia and renal failure.[95,96]

Because of the above limitations Surgeons have, therefore, advocated either preoperative ventriculostomy, intraoperative ventriculostomy, or spinal drainage to remove cerebrospinalfluid (CSF) and provide additional relaxation.[7,8,9,10]

There are several advantages of lumbar drainage of CSF over ventriculostomy to achievea dequate brain relaxation. There is less incidence of aneurysm rebleeding in patients undergoing lumbar drainage then ventriculostomy because of gradual reduction of ICP in lumbar drainage.[11,12,13,14,15,16] It avoids the need for the transcortical pass of ventricular catheter and is associated with less incidence of ventriculitis and meningitis.[17,18,19] Spinal drainage also allows for a slightly fuller ventricles and cisterns than ventricular drainage which facilitates arachnoidal dissection and minimizes epidural bleeding.

Spinal drainage provides access to a larger reservoir of CSF then ventriculostomy (130 cc versus 20 cc) permitting a greater degree of relaxation if required. Lumbar drainage allows controlled drainage of cerebrospinal fliud thus allowing gradual brain relaxation. When placed immediately before patient positioning, CSF drainage can be minimized during the early phase of surgery, preventing bothersome epidural venous bleeding. When brain retraction is required, incremental volume of CSF can be easily removed to allow atraumatic brain retraction.[20,21]

Complications of lumbar CSF drainage

Lumbar drain may be associated with various complications. Spinal nerve root injury, vital organ injury around spinal cord and post-dural puncture headache are reported as complications of lumbar CSF drainage. In addition cerebral herniation caused to death or severe neurological impairement are the most serious complications of lumbar CSF drainage especially in patients with increased intra-cranial pressure. For avoiding these complications NCCT head and lumbar X-rays were done before lumbar drain.

Other complications related to lumbar drains reported in the literature include PCA infract, vocal cord paralysis, spinal epidural haematoma, overdrainage, pneumocephalus and intracranial hypotension, infections.

This study was mainly undertaken in order to compare the effectiveness of pre-operative lumbar drainage with non-lumbar drainage in terms of surgical ease in dissection of sylvian fissure dissection of intracranial aneurysm, temporary clipping time, total surgery time and other post-operative parameters including post-operative vasospasm in patients undergoing clipping for ruptured intracranial aneurysm

Pre-operatively in one group of patients lumbar drain was put after induction of anaesthesia and in other group no lumbar drain was put.

A prospective randomized study was done on 50 patients of ruptured intracranial aneurysm undergoing clipping in the department of neurosurgery at PGIMS Rohtak. The patients were divided into two equal groups of 25 each. The first group was subjected for clipping of aneurysm with pre-operative lumbar drain placement after induction of anaesthesia and patients of group B were subjected to clipping of aneurysm without lumbar drainage.

Age

In this study 44.0% of the cases in the lumbar drain group and 52.0% of the case in without drain group were aged between 61 – 70 years of age which was not statistically significant between two groups. A similar study by Kwon et al had noted that, the mean age of lumbar drainage group was 57.5 years and non-lumbar drainage group was 57.7 years.[89] A study by Duan et al, the mean age was 60.13 years in Lumbar cistern group and 61.29 years in Lumbar puncture group.[92] Higher incidence of intra-cranial aneurysm is related to increased incidence of hypertension and atherosclerosis in older age group which are the risk factor for aneurysm formation.

Sex

This study had shown that majority of the subjects were females(56%) in both lumbar drain group and without lumbar drain groups. It has long been recoganized that cerebral aneurysms occur more frequently in women than in men.[97] The meta analysis by Rinkle and colleagues[98] of nine studies found a higher rupture rate in women, with a relative risk of 2.1.

A more expanded study by Wermer and clleagues[99] confirmed the higher risk of rupture in women , whereas de Rooij and co-workers [100] have found a higher risk for women only after age 60. Wermer's observations confirmed those of Locksley[101] from 1966 which revealed that below the age of 40, men predominated in the population of patients with rupture, whereas women were more frequently affected after the age of 40. Longstreth and colleagues[102] have proposed that hormonal factors may play a role in the pathogenesis of aneurysmal rupture.

Location of aneurysm

Anterior communicating artery and internal carotid had aneurysms as the common location in this study in both the groups which was not statistically significant. A study by Kwon et al had shown that, anterior communicating artery was commonly involved in lumbar drainage and non-lumbar drainage groups.[89] The reason for aneurysms commonly aising at the site of bifurcation of major arteries is related to increased wall stress at these sites.

WFNS on admission

This study had shown that, about 52.0% of the cases in lumbar drain group and 44.0% of the cases in without lumbar drain group had grade 4 WFNS which was not statistically significant.

Pre-operative Subarachnoid bleed

Subarachnoid bleeding was common in majority of the patients in both the groups which was not statistically significant.

Pre-operative Fischer's grade

More than half of the cases in both the groups had Fischer's grade 2 which was not statistically significant between the two groups. A study by Kwon et al had also shown similar results.[89]

Pre-operative hydrocephalus

56% of the patients in lumbar drain group and 44.0% of the patients in without lumbar drain group had pre-operative hydrocephalus which was not statistically significant.

Pre-operative aneurysm size

The aneurysmal size was less than or equal to 7 mm in 56.0% of the cases in both the groups which was not statistically significant. Vlak and colleagues[103] found that aneurysms smaller then 5 mm had an increased risk of rupture compared with larger aneurysms. Weibers and co-workers reported a zero risk of rupture for aneurysms less then 10 mm in diameter compared with an approximate risk for aneurysms larger then 10 mm of 1.7% per year[104].

Pre-operative time since bleed

The pre – operative time since bleed was less then 7 days in 56.0% of the lumbar drain group and 52.0% of without lumbar drain group which was not statistically significant.

Intra operative rupture

Intra operative rupture of aneurysm was present in 28.0% of the lumbar drain group and 28.0% of the without lumbar drain group which was not statistically significant.

Intra operative temporary clipping

The intra operative temporary clipping was conducted in 64.0% of the lumbar drain cases and 84.0% of the without lumbar drain group patients which was not statistically significant. Due to better understanding of neck of aneurysm and relationship with parent vessel and perforators the need for temporary clipping was less in lumbar drainage group.

Post-operative vasospasm

The post-operative vasospasm was present in 24.0% of the cases of lumbar drain group and 52.0% of the cases without lumbar drain group which was statistically significant.

Klimo *et al*[88] in a prospective nonrandomized trial involving 167 patients concluded that the LCSFD was superior to ventricular CSF drainage in the management of vasospasm. Symptomatic vasospasm occurred in 17% and 51% of patients with and without LCSFD, respectively, indicating that external clearance of spasmogenic substances reduces vasospasm in patients with thick SAH. Shunting of CSF through a lumbar drain conferred a statistically significant advantage with respect to marked reduction in the risk of clinically evident vasospasm and its sequelae, shortening of hospital stay, and improvement in outcome. In comparison with ventricular CSF drainage, LCSFD is more safe without being a direct cause of brain parenchymal damages such as intracranial hemorrhage.

Kwon *et al*.[89] also established the effectiveness of LCSFD in preventing clinical vasospasm and its sequelae after endovascular coiling on aneurysmal SAH. The incidence of clinical vasospasm in the lumbar drain group was 23.4% compared to 63.3% the control group. Moreover, the risk of death in the lumbar drain group was 2.1% compared to 15% in the control group.

It is believed that drainage of CSF from the lumbar cistern would promote circulation of newly produced CSF and blood cells from the ventricles through the subarachnoid space thus decreasing the risk of vasospasm. Lumbar drainage would also promote removal of the red cell mass from the intrathecal space, which represents the largest of all subarachnoid cisterns.

Less incidence of vasospasm is also attributed to reduced intra-cranial pressure offered by lumbar drainage by improved circulation of csf and decreased incidence of hydrocephalus.

In lumbar drainage group intra-thecal papavarine was also given post-operatively which decreased the incidence of vasospasm.

Post-operative early infarct

Post-operative early infarct was present in 8.0% of the cases in lumbar drain group and 32.0% of the cases without lumbar drain group which was statistically significant. In lumbar drain group there was less incidence of vasospasm so chances of early infract reduced in lumbar drain group.

Post-operative late infarct

The post-operative late infarct was present in 4.0% of the lumbar drain group and 24.0% of the patients without lumbar drain group which was statistically significant. There was less incidence of ischaemic injury to brain as there was less need of brain retraction in lumbar drain group, decreased total temporary clipping time and total surgery time in lumbar drain group.

Study by Klimo P et al demonstrated reduced occurance of vasospastic infraction from 27 to 7 % in lumbar drain group.[88]

LUMAS trial. This RCT recruited 210 patients with aSAH, and demonstrated that ELD of CSF after aSAH reduces the prevalence of delayed ischemic neurological deficit and improves early clinical outcome but fails to improve outcome at 6 months after aSAH. The prevalence of delayed ischemic neurological deficit was 35.2% and 21.0% in the non lumbar drainage and lumbar drainage groups, respectively (*P*=0.021)[90]

Post-operative CSF diversion

About 16.0% of the cases in lumbar drain group and 36.0% of the cases in without lumbar drain group had post-operative CSF diversion which was statistically not significant. A study by Klimo Jr had shown that, there was no statistical difference between the groups in terms of patients requiring a shunt.[88] In a study by Kwon et al, the shunt was used in 17.0% of the lumbar drainage cases and 8.3% of the non-lumbar drainage group patients.[89]which was also statistically not significant.

Acute and chronic hydrocephalus is thought to result from tentorial/ventricular obstruction and blockage of arachnoid granulations with blood, respectively. Either mechanism is likely to be resisted and minimized by the negative downward pressure drawing CSF and blood products into the lumbar cistern, an advantage of lumbar drainage over supratentorial CSF drainage.

Post-operative re exploration/ decompression

Post-operative reexploration / decompression was conducted in 4.0% of the lumbar drain group and 20.0% without lumbar drain group which was not statistically significant. Increased incidence of post-operative re-exploration in non-lumbar drainage group is seems to be related to increased vasospastic complications in non- Lumbar drainage group. Better ICP control in lumbar drainage group is also responsible for decreased need of re-exploration.

Post-operative ventilatory support

Post-operative ventilatory support was given in 24.0% of the lumbar drain group cases and 24.0% of the cases without lumbar drain group which was not statistically significant.

Post-operative ICU stay

Post-operative ICU stay was more then 7 days in 16.0% of the cases in lumbar drain group and 44.0% of the cases without lumbar drain group which was statistically significant. A study by Klimo et al also shown similar results.[88] In a study by Kwon et al mean stay in ICU was 18.8 days in lumbar drainage and 18.6 days in non-lumbar drainage group.[89] Reduced vasospastic complications and better ICP control offered by lumbar drainage is responsible for reduced ICU stay in Lumbar drainage group.

Post-operative WFNS

Post-operative WFNS was grade 1 in 60.0% of the lumbar drain group and 52.0% of the without lumbar drain groups. A study by Klimo Jr et al also had shown similar results.[89]

On discharge motor deficit

On discharge motor deficit was present in 20.0% of the cases in lumbar drain group and 24.0% of the cases in without lumbar drain group which was not statistically significant.

On discharge sensory deficit

Sensory deficit was present in 12.0% of the lumbar drain group and 16.0% of the without lumbar drain group which was not statistically significant.

Time taken for dissection of sylvian fissure

Mean time taken for dissection of sylvian fissure in lumbar drain group was 22.16 minutes and 33.04 minutes in patients without lumbar drain group which was statistically significant. In our study brain relaxation achieved with the help of intra-operative lumbar drainage is responsible for reduced time in sylvian fissure dissection. In relaxed brain sub-arachnoid membranes become lax and spaces open up. There are less chances of injury to sylvian vein and its tributaries in relaxed brain.

Time taken for dissection around aneurysm

Mean time taken for dissection around aneurysm was 29.64 minutes in lumbar drain group and 39.92 minutes in without lumbar drain group which was statistically significant between the two groups. In relaxed brain there is good exposure of parent vessels, branches and perforators were easily identified, neck of aneurysm and its relation to parent vessel was more easily and clearly identified.

Total temporary clipping time

The mean temporary clipping time in lumbar drain group was 5.72 minutes and 11.6 in non-lumbar drain group which was statistically significant. Detrimental effects of temporary clipping of major vessels like vasospasm, ischemic injury to brain and infraction has been reduced by intra-operative lumbar drainage by providing adequate brain relaxation and decrease the toal time of temporary clipping.

Total time of surgery

The total time of surgery in lumbar drain group was 87.5 minutes and 103.5 minutes in non-lumbar drain group which was statistically significant. Brain relaxation offered by intra-operative lumbar drainage provided surgical ease to operative surgeon and thus reducing total surgery time and having favourable impact on overall outcome of patient.

In relaxed brain there was less need for brain retraction and if retraction was needed it was easier, there was decreased sylvian fissure dissection time, cisternal opening was easier, there was earlier identification of aneurysm and its parent vessel- perforator relationship, there was was decreased temporary clipping time.

Advantages offered by decreased total surgery time were

1. Decreased brain retraction injury
2. Decreased incidence of vasospasm
3. Decreased incidence of infraction
4. Decreased blood loss

Need for ventricular drainage

In this study, none of the patients in lumbar drain group and 24.0% in non-lumbar drain group needed ventricular drainage which was statistically significant. In non –lumbar drainage group 6 patients have tense brain after craniotomy and there was need for ventricular drainage.

Time taken for clipping after operative rupture

The mean time of clipping of aneurysms which had intra operative rupture was 16.88 minutes in the lumbar drain group and 21 minutes in non-lumbar drain group which was statistically significant. In relaxed brain there was earlier identification of aneurysm and its parent vessel-perforator relationship.

CONCLUSION

This study was undertaken mainly to compare the effectiveness of pre-operative lumbar drainage versus Non-lumbar drainage in surgical dissection of intra-cranial aneurysm of patients undergoing clipping for ruptured intracranial aneurysm and to compare outcome and complications in two groups.

Adequate brain relaxation is important to avoid complications related to forceful and /or prolonged lobar retraction. This study describes effectiveness of pre-operative lumbar drainage in providing surgical ease in dissection of aneurysm and clipping and also reducing temporary clipping time and total surgery time.

Lumbar drainage is an effective method of brain relaxation during micro-surgical clipping of aneurysm. Lumbar drainage allows controlled drainage of cerebrospinal fliud thus allowing gradual brain relaxation. When placed immediately before patient positioning, CSF drainage can be minimized during the early phase of surgery, preventing bothersome epidural venous bleeding.

When brain retraction is required, incremental volume of CSF can be easily removed to allow atraumatic brain retraction. In certain aneurysms like Paraclinoid aneurysms need for extra dural drilling of bone is reduced by intra-operative lumbar drainage.

Lumbar drainage provides surgical ease in microsurgical clipping of aneurysm by providing adequate brain relaxation and avoiding complications related to other methods of achieving brain relaxation.

This prospective, randomized controlled study has demonstrated the efficacy of LCSFD to significantly reduce clinical vasospasm and vasospasm-related cerebral infarction in patients with aneurysmal SAH, thereby contributing to a better outcome. Lumbar CSF drainage is believed to decrease cerebral vasospasm by promoting circulation of CSF and clearance of blood from the subarachnoid spaces.

It is concluded in our study that- v The outcome of Lumbar drainage and non lumbar drainage were comparable in terms of need for post-operative CSF diversion, post-operative re-exploration/ decompression, post-operative ventilator support, post operative WFNS grade, on discharge neurological impairement.

- Lumbar drainage group was better with in terms of time taken for dissection of sylvian fissure, time taken for dissection around aneurysm, helps in providing surgical ease
- post-operative vasospasm was less in lumbar drainage group, post –operative early and late infracts were less in lumbar drainage group.
- Lumbar drainage group is better then non lumar drainage group in terms of operative time.
- Lumbar drainage group is better in terms of length of ICU stay.
- But this study is not without limitations. The sample size was smaller to compare the two groups. Though this study has brought out many important facts about pre-operative lumbar drainage in aneurysm surgery, in future the researchers can take up more studies to compare these techniques.

Abbreviation

SAH- Subarachnoid haemorrhage
DSA- Digital substraction angiography
IVH- Intraventricular haemorrhage
CSF- Cerebrospinal fluid
ICP- Intracranial pressure
AVM- Arteriovenous malformation
HMG- Beta hydroxyl Beta methyl glutaryl Coenzyme A
IEL- Internal elastic lamina
ICA- Internal carotid artery
FLAIR- Fluid attenuated inversion recovery
GRE- Gradient recalled echo
SWI- Susceptibility weighted imaging
CTA- Computed tomography angiography
MRA- Magnetic resonance angiography
ISAT- International Subarachnoid aneurysm Trial
GOS- Glasgow outcome score
NIHSS- National institute of health stroke scale
LUMAS- Lumbar drainage of CSF after aneurysmal sub-arachnoid haemorrhage

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