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Original Article

Does establishing a neurovascular unit improve the outcome after surgical clipping for aneurysmal subarachnoid hemorrhage? Results from a 5-year observational study in Kuwait

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ABSTRACT

Background: Failure to prevent rebleeding after cerebral subarachnoid hemorrhage (SAH) is the most frequent reason for high morbidity and mortality of aneurysmal SAH. Our study aims to identify the outcome after surgical clipping of aneurysmal SAH before and after the establishment of the neurovascular unit. The clarifications of the positive turnover in the outcome will be discussed.

Methods: A retrospective cohort analysis was carried out on our experience with a controlled group of patients who underwent clipping for ruptured cerebral aneurysms (n = 61) from January 2015 to December 2019. A modified Rankin scale (mRS) was used to determine the outcome after 6 months of follow-up.

Results: The median mRS score (i.e., outcome) on admission was 4, whereas it was with a median score of 2 six months after clipping ($P \leq 0.001$). Overall, the cases with a good outcome were 63.9% of the sample, while the poor outcome conditions were 36.1%. The most cases with an improved outcome were after introducing the neurovascular unit, representing a transition of aneurysmal clipping practice in our center. The good outcome was changed from 42% to 76.7%, and the poor outcome was changed from 58% to 23.3% ($P = 0.019$). The crude mortality rate was similar to the rate worldwide (18%), with a noticeable decrease after organizing a neurovascular subspecialty.

Conclusion: The outcome after clipping of ruptured SAH can be largely affected by the surgeon's experience and postoperative intensive care. Organizing a neurovascular team is one of the major factors to achieve good outcomes.

Keywords: Cerebral aneurysm, Clipping, Outcome, Subarachnoid hemorrhage, Surgeon experience

INTRODUCTION

A ruptured cerebral aneurysm would remain a major reason for high morbidity and mortality, especially if there were no early interventions.[1,3] Rebleeding is the most lethal complication of subarachnoid hemorrhage (SAH) that must be prevented early on. Securing the cerebral aneurysm after bleeding and preventing further bleeding can be attained with two treatment modalities, which are surgical clipping and coiling.[20]

Both clipping and coiling have pros and cons, which makes them complementary to each other rather than competitive.[20] Following the international subarachnoid aneurysm trial (ISAT) in 2002, endovascular coiling has replaced surgical clipping in many centers.[13] However, the same trial showed that endovascular coiling had a higher risk of rebleeding compared to clipping.[13,18,20] It is also relevant to draw attention that endovascular coiling was done by highly experienced interventional radiologists in the ISAT. A multicenter controlled study revealed that endovascular coiling after SAH is associated with a higher 14-day case fatality compared to clipping.[8] In addition, the Barrow trial revealed that less than 1% of clipped patients required reintervention, but around 20% of coiled patients required reintervention.[19] Yet, meta-analyses disclosed that microsurgical clipping provides better results in terms of rebleeding.[2] Certainly, the management decision (i.e., coiling or clipping) depends on different factors, including the patients' comorbidities as well as the size, location, and shape of the aneurysm. But undoubtedly, the risk of rebleeding and decreasing the rate of complications after clipping varies with the experience of the cerebrovascular surgeon.[11]

Of course, the dominant treatment modality for ruptured cerebral aneurysms is coiling. Thus, coiling as a treatment modality began to emerge in Kuwait in 2014. However, several cases that we faced were not amenable to coiling. Hence, surgical clipping certainly remains a major treatment option for aneurysmal SAH. Almost all the patients presented here underwent a trial of coiling before the surgical clipping. In this analysis, we do not compare the two modalities for resolving ruptured cerebral aneurysms, but we aim to compare the safety, efficacy, and outcome of treating patients with clipping before and after the establishment of the neurovascular unit. This is the first analysis in Kuwait that outlines the experience of surgical clipping of ruptured SAH. Our prespecified hypothesis intents to show that the surgeon's experience in a coherent center is one of the most important factors affecting patients' outcome. We also underline the predictors that should be addressed to improve the outcome.

MATERIALS AND METHODS

Study design, setting, and participants

In this retrospective cohort, we enrolled 61 patients from Ibn Sina Hospital in Kuwait from January 2015 until December 2019. We studied all available records for patients who underwent surgical clipping for a cerebral aneurysm in that period. This scheme was used to ensure the representativeness of all cases in Kuwait since it is the only hospital that performs this operation. Our inclusion criterion was any patient who underwent a neurosurgical clipping procedure in our center and was diagnosed with a ruptured aneurysmal SAH that was confirmed before surgery by digital subtraction angiogram except for one case that was operated based on computerized tomography (CT) angiography. Exclusion criteria included clipping performed for nonruptured cerebral aneurysms, cases that underwent endovascular coiling, and SAH cases that were not attributable to a ruptured aneurysm.

The operative theater database of our center was utilized to select the cases in Kuwait. A standardized protocol was followed for data collection to avoid information bias. Each participant with cerebral aneurysmal SAH was followed from the records for 6 months. All our patients after surgical clipping received similar care (protocol for subarachnoid hemorrhage). After the operation, the patient was admitted to the intensive care unit (ICU) for at least 14 days from the onset of the bleeding, regardless of the clinical condition. All patients received nimodipine and antiepileptic, and were followed up daily by a neurointensivist and a neurosurgeon. CT cerebral perfusion was performed to look for vasospasm after the 4th, 6th, and 10th day post-SAH. Afterward, the patients were either shifted to the floor or another medical center for further management and rehabilitation until they were discharged if they were well enough.

Data, variables, and outcome

The ethical approval for the conduction of this study was verified by the Standing Committee for Protection of Human Subjects in Research in Kuwait. Patients were viewed back in time by the use of their medical records. These documents included the charts, physician notes, nursing notes, physiotherapist notes, operative notes, ICU notes, radiological images, as well as the system data. We declare that all the information in our paper were derived from patients' medical file records. A convenient sampling method was used for data collection, and the distribution of qualitative responses was described as frequency and percentages. They were classified based on gender, age (<30 years old, 30–50 years old, or more than 50 years old), and Charlson comorbidity index (CCI)[5] (0: no comorbidity, 1–2: mild, 3–4: moderate, or ≥ 5: severe). Other subgroups involved the size of a cerebral aneurysm (micro: ≤5 mm, small: 6–10 mm, or large: ≥11 mm). The World Federation of Neurosurgical Societies (WFNS) grade before the intervention, which contains the Glasgow Coma Scale (GCS) and presence of focal neurological deficits to classify the severity, was also added.[16] For severity assessment based

on the CT scan, we used the modified Fisher Grading Scale before admission.[10]

Concerning the outcome, the modified Rankin scale (mRS) score during admission and after 6 months was determined for each participant.[12,20,23] The scale scores from 0 to 6, running from normal health without symptoms to death.[23] This score moves as follows (0 – no symptoms; 1 – minor symptoms without significant disability; 2 – restriction of lifestyle with a slight disability; 3 – significant restriction of lifestyle with a moderate disability; 4 – unable to attend to own bodily needs and requires some help (partly dependent); 5 – severe disability, bedridden, and requires constant nursing care (fully dependent); and 6 – dead). A good functional outcome was classified as a mRS score of 0–2 after 6 months, whereas a poor functional outcome was classified as a mRS score of 3–6 after 6 months.[8] In addition, we reviewed the radiological images for any vasospasm or hydrocephalus.

Statistical methods

The data were entered and analyzed through IBM Statistical Package for the Social Sciences. The data were inspected for logical data entry errors and cleaned. All qualitative variables were summarized into frequencies and percentages. The non-normally distributed continuous outcome variable (mRS) was summarized with the use of the median and interquartile range (IQR). The difference of medians for the continuous variable was measured to look for any association. Pearson's Chi-square was used to measure the significance of the associations between the categorical variables. Mann–Whitney U-test was utilized to compare two groups with a non-normal frequency distribution, while Kruskal–Wallis one-way test of variance was used for more than two groups. We tested the hypothesis of our questions in relation to age, gender, CCI, size of the aneurysm, WFNS grade, modified Fisher scale, and development of hydrocephalus and/or vasospasm. $P \leq 0.05$ was considered statistically significant.

RESULTS

In our analysis, 66 patients (out of a total of 180 SAH cases) underwent surgical clipping for a ruptured SAH. Out of this number, 61 patients, representing the sample size, were followed for 6 months. Most of the participants (92%) underwent a trial of coiling before the surgical clipping. There were five patients with missing data who were opted out of the study.

In [Table 1], the sample size (n = 61) consists of 34 (55.7%) females and 27 (44.3%) males, with a mean age of 45 ± 13.4 years (12–79 years). Regarding the age, 7 (11.5%) were below 30 years old, 35 (57.4%) were between 30 and 50 years old, and 19 (31.1%) were above 50 years old. The majority (82%) were non-Kuwaiti, most of them from Asia's eastern region. Furthermore, [Table 1] shows the Charlson comorbidity index: no comorbidities = 59%, mild = 21.3%, moderate = 13.1% and severe = 6.6%. According to our results, 39 (63.9%) had a micro cerebral aneurysm. All of the patients in the analysis had an anterior circulation cerebral aneurysm, except one case of posterior circulation (posterior inferior cerebellar artery) ruptured aneurysm that was clipped with a good outcome. From our results, most of the patients had a grade two WFNS before the surgical intervention. Regarding the modified Fisher scale, scales one and two represent 42.6%, while scales three and four represent 57.4% of the participants. Surprisingly, most surgical clipping operations (78.7%) were delayed until the following day after the diagnosis. Likely, this was because of transfer slowdown from other centers or diagnostic cerebral angiography setback.

Table 1: Descriptive characteristics of the patients who underwent surgical clipping for a ruptured cerebral aneurysm in Kuwait (n=61).

Characteristic	*n*	%
Gender		
Male	27	44.3
Female	34	55.7
Age in years		
<30	7	11.5
30–50	35	57.4
>50	19	31.1
Nationality		
Kuwaiti	11	18
Non-Kuwaiti	50	82
Charlson comorbidity index (CCI)		
No comorbidities	36	59
Mild	13	21.3
Moderate	8	13.1
Severe	4	6.6
Size of cerebral aneurysm		
Micro	39	63.9
Small	20	32.8
Large	2	3.3
WFNS grade before intervention		
Grade 1	4	6.6
Grade 2	35	57.4
Grade 3	6	9.8
Grade 4	12	19.7
Grade 5	4	6.6
Modified Fisher scale on admission		
1–2	26	42.6
3–4	35	57.4
Surgery time postincidence		
Same day of incidence	2	3.3
Day 1 postincidence	48	78.7
After day 1 of incidence	11	18

% = column %, WFNS: World Federation of Neurosurgical Societies grading system

As declared, the median mRS score after 6 months represented our endpoint. The lower the median mRS, the better is the functional outcome. After a 6-month follow-up duration, the good outcome conditions (mRS = 0–2) represented 63.9%, whereas, the poor outcome conditions (mRS = 3–6) represented 36.1%. On hospital admission, the median mRS score of the sample was 4 (IQR: 3–5), while the median mRS score after 6 months was 2 (IQR: 0–4.5). The difference between the medians of mRS was statistically significant (difference = 2, $P \leq 0.001$). After 6 months, the outcome was considerably better in comparison to the admission status in a large number of cases [Table 2] and [Figure 1]. The difference in the median during the presentation and 6 months after the clipping is illustrated in [Figure 2].

In 2015–2017, it appeared that outcomes did not reach a satisfactory level. After establishing the neurovascular unit in 2018, it seemed that the functional outcome has been significantly improved [Table 3]. [Figure 3] shows that the good outcome was changed from 42% to 76.7%, and the poor outcome was changed from 58% to 23.3%. [Figure 4] displays the pyramid distribution after 6 months for both poor and good outcome cases regarding the intervention year. The worst functional outcomes and the highest mortality were in 2017. However, in 2018 and 2019, there has been a remarkable positive change in the outcome of aneurysmal clipping in Kuwait. Furthermore, the total crude mortality cases postemergency clipping for ruptured SAH were 11 out of 61 (around 18%) from the start of 2015 until the end of 2019.

The association between the outcomes was tested to the categorical variables [Tables 4 and 5]. There was no relation in the outcome with regard to age. Although the outcome and mortality were worst among males than females, this difference was not statistically significant. As expected, the higher the comorbidity index, the worst is the outcome (P = 0.040). Patients with ruptured microaneurysm have a better outcome than those with small or large cerebral aneurysm rupture. Moreover, there was a significant difference (P = 0.001) between the medians of mRS with reference to WFNS grades. The median outcome was 0 in one–two Fisher scales, while the median was 2 in three–four Fisher scales, with a significant variation ($P \leq 0.001$).

Table 2: Distribution of mRS outcome during admission and after 6 months (n=61).

mRS	During admission		After 6 months	
	n	%	*n*	%
No symptoms	1	1.6	18	29.5
Minor symptoms	3	4.9	10	16.4
Some restriction in lifestyle	5	8.2	10	16.4
Significant restriction in lifestyle	18	29.5	3	4.9
Partly dependent	14	23.0	5	8.2
Fully dependent	20	32.8	4	6.6
Dead	NA	NA	11	18.0

% = column %, mRS: Modified Rankin scale

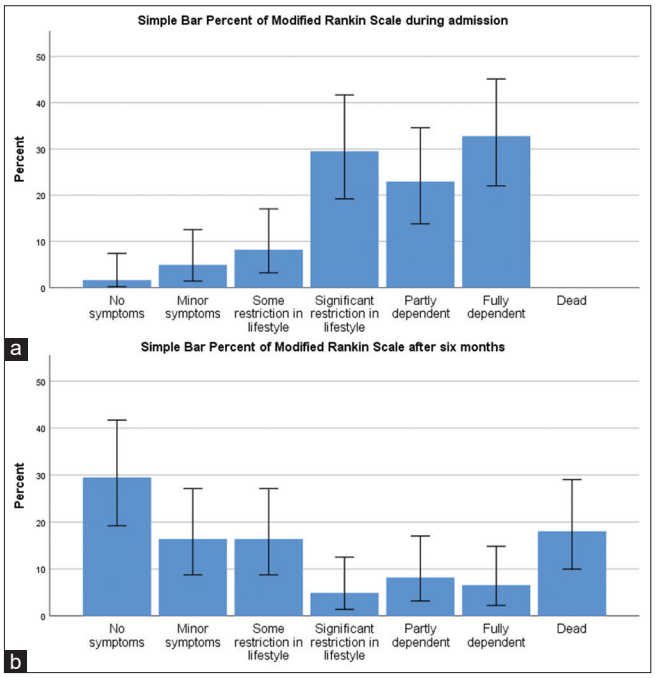
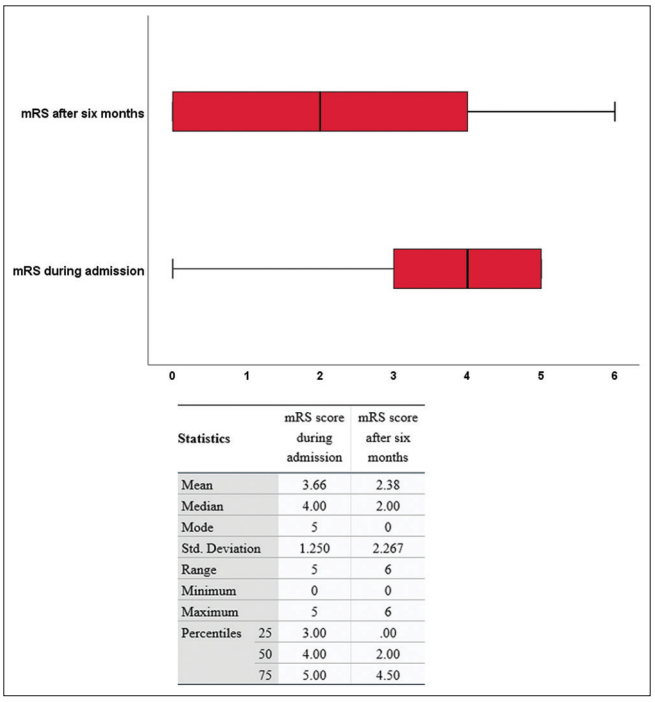


Figure 1: (a and b) Bar charts of the functional outcome (mRS) during the admission and after the surgical clipping. Error bars: 95% confidence interval.



Statistics		mRS score during admission	mRS score after six months
Mean		3.66	2.38
Median		4.00	2.00
Mode		5	0
Std. Deviation		1.250	2.267
Range		5	6
Minimum		0	0
Maximum		5	6
Percentiles	25	3.00	.00
	50	4.00	2.00
	75	5.00	4.50

Figure 2: Boxplot and statistical comparison between the mRS scores during admission and 6 months after the surgical clipping. mRS: Modified Rankin scale

Table 3: The association between the outcome (mRS score after 6 months) and the surgical intervention before and after the establishment of the neurovascular unit (*n*=61).

Item	All *n*=61	mRS score after 6 months							*P*-value
	n	Score 0	Score 1	Score 2	Score 3	Score 4	Score 5	Score 6	
Year of clipping									0.019
Before the neurovascular unit 2015–2017	31	7 (22.6)	4 (12.9)	2 (6.5)	4 (12.9)	3 (9.6)	2 (6.5)	9 (29.0)	*n* (%)
After the neurovascular unit 2018–2019	30	11 (36.7)	7 (23.3)	5 (16.7)	3 (10.0)	1 (3.3)	1 (3.3)	2 (6.7)	*n* (%)

n % = row %, the percentage numbers were rounded to the nearest 10. *P*-value was generated using Pearson's Chi-square test (≤0.05 is statistically significant). Good outcome = MRS: 0–2, poor outcome = MRS 3–6. Modified Rankin scale score (0 = no symptoms, 1 = minor symptoms, 2 = some restriction in lifestyle, 3 = significant restriction in lifestyle, 4 = partly dependent, 5 = partly dependent, 6 = dead). MRS: Modified Rankin scale

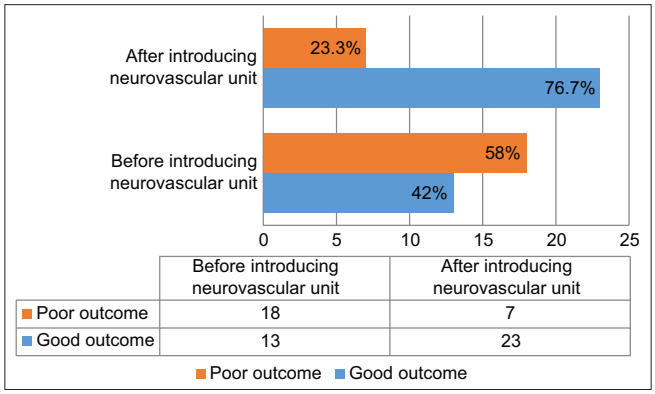


Figure 3: The functional outcome before and after introducing the neurovascular unit.

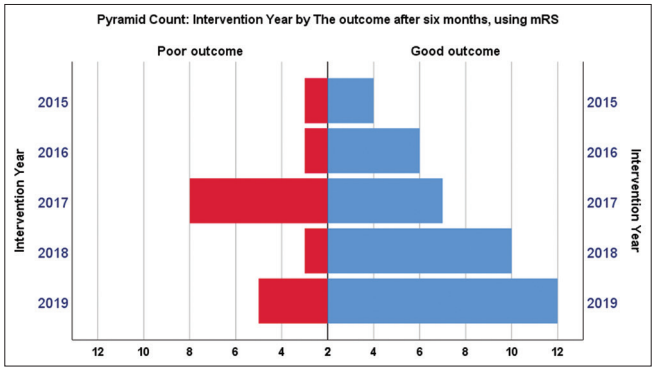


Figure 4: Pyramid sample count, representing the poor and good functional outcome in relation to the year of intervention. mRS score: modified Rankin scale score. Good outcome = mRS: 0–2, poor outcome = mRS 3–6. mRS: Modified Rankin scale

Participants who develop hydrocephalus had a poorer outcome, but this relation was not statistically remarked. The radiological vasospasm was noticed among 24 patients (39.3%). Unsurprisingly, the development of cerebral vasospasm was associated with a poor outcome.

DISCUSSION

Establishing the cerebrovascular unit in 2018 has enhanced the functional outcome and decreased mortality. This could be explained by expanding the vascular experience in our department along with promoting surgical and postsurgical care.

Apparently, the surgical clipping rate and its success for aneurysmal SAH are different from one center to another worldwide. The different results depend on several variables. As expected, surgical experience, which is often measured by annual case volume, plays a major role.[11] Neurosurgeons with more than 10 years of neurovascular surgery practice could be categorized as experienced neurovascular surgeons.[11] The poor outcome risk from inexperienced neurosurgeons was obviously higher than that of an experienced neurovascular surgeon.[11] Almost certainly, the experience in the center, not patient volume, is more important for better results.[4] In addition to the preoperative condition, which plays a critical role in the outcome, securing the aneurysm to prevent rebleeding is very crucial to avoid poor outcomes. Here, the improvement of Kuwait's neurosurgery practice and the recruitment of different expertise contributed to better results, especially after establishing the cerebrovascular unit. Furthermore, the development of surgical strategies and facilities, such as modern microsurgical tools, has restructured the practice. Apart from that, supporting the ICU with evidence-based management guidelines has further improved the end-results. Based on the results in 2018 and 2019, we firmly believe that the enrollment of more experienced neurosurgeons and critical care physicians will ultimately improve the outcomes for these patients, especially for those who cannot be coiled. However, the delay in the referral of patients from other hospitals to our center, which is the only neurosurgical center in Kuwait, has affected our results. Despite that, we have a good net result, but we insist that enhancing patient transfer will surely contribute to better care.

Clipping of cerebral aneurysm is one of the most complex surgical interventions. We believe that the experience of the surgeon is one of the most important factors to secure the aneurysm effectively. A large retrospective cohort performed in the USA explored that 37.6% of patients with aneurysmal SAH underwent clipping, and 62.4% were

Table 4: The association between the outcome (mRS score after 6 months) in relation to following items (*n*=61).

Item	All *n*=61	mRS score after 6 months							*P*-value
	n	Score 0	Score 1	Score 2	Score 3	Score 4	Score 5	Score 6	
Age categories, in years									0.486
<30	7	1 (14.3)	1 (14.3)	3 (42.8)	0 (0)	0 (0)	0 (0)	2 (28.6)	*n* (%)
30–50	35	12 (34.3)	6 (17.1)	3 (8.6)	1 (2.9)	3 (8.6)	4 (11.4)	6 (17.1)	*n* (%)
>50	19	5 (26.3)	3 (15.8)	4 (21.1)	2 (10.5)	2 (10.5)	0 (0)	3 (15.8)	*n* (%)
Gender									0.425
Male	27	5 (18.5)	6 (22.2)	4 (14.8)	1 (3.7)	3 (11.1)	1 (3.7)	7 (26.0)	*n* (%)
Female	34	13 (38.2)	4 (11.8)	6 (17.6)	2 (5.9)	2 (5.9)	3 (8.8)	4 (11.8)	*n* (%)
Charlson comorbidity index									0.045
No comorbidity	36	12 (33.3)	6 (16.7)	6 (16.7)	0 (0)	2 (5.6)	3 (8.3)	7 (19.4)	
Mild	13	5 (38.5)	1 (7.7)	1 (7.7)	3 (23.0)	0 (0)	1 (7.7)	2 (15.4)	
Moderate	8	1 (12.5)	2 (25.0)	2 (25.0)	0 (0)	1 (12.5)	0 (0)	2 (25)	
Severe	4	0 (0)	1 (25)	1 (25)	0 (0)	2 (50)	0 (0)	0 (0)	
Size of aneurysm									0.012
Micro	39	15 (42.9)	7 (20)	8 (22.9)	1 (2.8)	3 (8.6)	0 (0)	1 (2.8)	*n* (%)
Small	20	3 (21.5)	3 (21.5)	2 (14.2)	1 (7.1)	2 (14.2)	0 (0)	3 (21.5)	*n* (%)
Large	2	0 (0)	0 (0)	0 (0)	1 (50)	0 (0)	0 (0)	1 (50)	*n* (%)
WFNS									0.008
Grade 1–2	39	17 (43.6)	7 (17.9)	6 (15.4)	1 (2.6)	2 (5.1)	3 (7.7)	3 (7.7)	*n* (%)
Grade 3–5	22	1 (4.6)	3 (13.6)	4 (18.2)	2 (9.1)	3 (13.6)	1 (4.6)	8 (36.3)	*n* (%)
Modified Fisher scale									0.004
1–2	26	15 (57.7)	3 (11.5)	4 (15.3)	0 (0)	1 (3.9)	1 (3.9)	2 (7.7)	*n* (%)
3–4	35	3 (8.6)	7 (20)	6 (17.1)	3 (8.6)	4 (11.4)	3 (8.6)	9 (25.7)	*n* (%)
Cerebral vasospasm-related infarction									0.026
Yes	24	10 (41.6)	5 (20.8)	4 (16.7)	0 (0)	1 (4.2)	0 (0)	4 (16.7)	*n* (%)
No	37	8 (21.7)	5 (13.5)	6 (16.2)	3 (8.1)	4 (10.8)	4 (10.8)	7 (18.9)	*n* (%)
Hydrocephalus									0.125
Yes	17	4 (23.6)	1 (5.9)	3 (17.6)	1 (5.9)	0 (0)	3 (17.6)	5 (29.4)	*n* (%)
No	44	14 (31.8)	9 (20.5)	7 (15.9)	2 (4.5)	5 (11.4)	1 (2.3)	6 (13.6)	*n* (%)

n % = row %, the percentage numbers were rounded to the nearest 10. *P*-values were generated using Pearson's Chi-square test (≤0.05 is statistically significant). mRS score (0 = no symptoms, 1 = minor symptoms, 2 = some restriction in lifestyle, 3 = significant restriction in lifestyle, 4 = partly dependent, 5 = partly dependent , 6 = dead). WFNS: World Federation of Neurosurgical Societies grading system, mRS: Modified Rankin scale

coiled.[3] In our center, around 35% of the ruptured SAH cases were clipped. The flow of aneurysmal clipping cases in our center was escalating in relation to the year [Figure 5]. This increase of cases could be explained by the increment of the annual population growth rate, especially the foreign workers from the eastern region of Asia, including Filipinos, Indians, and Bengalis.[24] Nevertheless, the availability of all modern facilities as well as the skillset and the recent heed in neurovascular surgeries built on the confidence of performing this operation in our department.

The literature has accepted that the management of aneurysmal SAH demands multiple efforts from different specialties.[15,17] Our paper supports the multiple disciplinary measures that were implemented recently in our center, but there is still more to build on. For our results, the good outcome was 63.9% after 6 months. In another study, the good outcome using the mRS (0–2) was 49% after 1 year in the clipping group.[9] Admission mRS, Fisher grading,

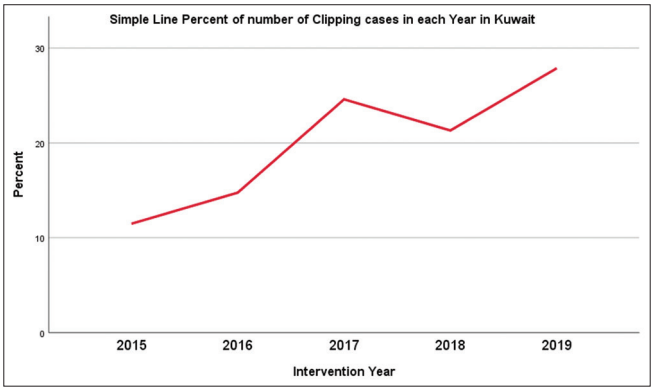


Figure 5: Percentage of cases (clipping of cerebral aneurysm) in relation to the year of intervention in Kuwait.

vasospasm-related infarction, and hydrocephalus had surely a significant association with poor outcome.[7] Likewise, our results disclosed that these items were significantly associated with poor outcomes.

Intraoperative angiography helps place the clip and confirms parent vessel patency after securing the aneurysm, and it permits immediate clip revision when necessary.[6,21] In Kuwait, intraoperative angiography is not available. However, CT cerebral angiography was performed after clipping for all cases. It confirmed that none of the cases in our follow-up had a residual aneurysm.

From the cohort, the annual mortality percentage after clipping was as follows: 28.5% in 2015, 11.1% in 2016, 40% in 2017, 7.7% in 2018, and 5.9% in 2019 [Table 3]. The mean mortality declined from 26.5% in 2015–2017 to 6.8%. In a retrospective study in Australia, the death rate declined from 35.4% in 2000 to 27.2% in 2015.[22] In our sample, overall in-hospital crude mortality between 2015 and 2019 was 18%. Most of these cases were dead within the first 30 days after surgery, while only two cases were declared dead between 30 and 90 days postoperative. Similarly, the mortality rate after clipping of aneurysmal SAH was 17.9% in another study.[4] Based on several reports, the 30-day mortality is from 18% to 40%.[4,14,22]

Table 5: Association of the median of mRS score after 6 months in relation to the following items.

Characteristic	mRS after 6 months median (IQR)	*P*-value
Age categories, in years*		0.456
<30	2 (1, 6)	
30–50	1 (0, 5)	
>50	2 (0, 4)	
Gender		0.146
Male	2 (1, 6)	
Female	1.5 (0, 4)	
Charlson Comorbidity index*		0.040
No comorbidity	1.5 (0, 5)	
Mild	2 (0, 4)	
Moderate	2 (1, 5.5)	
Severe	3 (1.25, 4)	
WFNS*		
Grade 1	6 (1.5, 6)	0.001
Grade 2	1 (0, 2)	
Grade 3	4 (0.75, 6)	
Grade 4	3.5 (2, 5.5)	
Grade 5	5.5 (2.75, 6)	
Modified Fisher scale		<0.001
1–2	0 (0, 2)	
3–4	3 (1, 6)	
Hydrocephalus		0.099
Yes	3 (0.5, 6)	
No	1 (0, 4)	

mRS score: Modified Rankin scale score, IQR: Interquartile range. Median score of mRS after 6 months = 2, IQR = 0, 4.5. *P*-values were generated using the Mann–Whitney U-test for comparing two groups, and *Kruskal–Wallis one-way analysis of variance test for comparing more than 2 groups (≤0.05 is statistically significant)

We summarized a scheme of our experience in [Figure 6]. It shows the predisposing factors that can enhance or lower the healthcare system for the surgical management of SAH.

Preoperative neurological status to consider surgical intervention

In our center, we considered clipping for all SAH cases with WFNS grades from 1 to 5, except those with a GCS of less than 5. After stabilizing the cases with a very poor prognosis (GCS 3 or 4), the decision could be determined after the proper neurological status reassessment and angiography findings.

The cases in our sample were not amenable for coiling. All patients underwent cerebral angiography before the surgical intervention, except one case. We faced a condition of anterior communicating artery aneurysm that we found that it is rationale to operate it emergently based on the CT angiography only due to severe mass effect of the intracerebral hematoma, which caused a significant midline shift (mRS after the follow-up = 1).

Strengths and limitations

This is the first study in Kuwait and the Middle East region that questions this hypothesis. Moreover, we collected data from a relatively long duration (5 years). The follow-up to

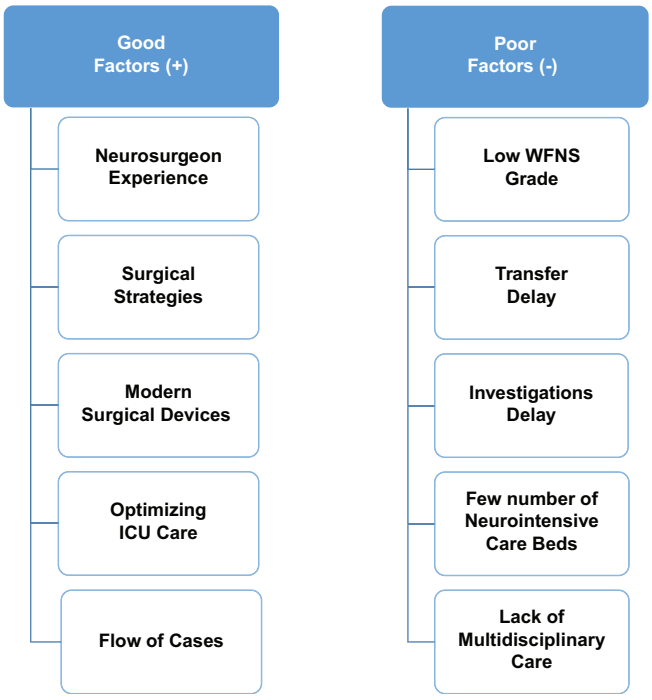


Figure 6: Predisposing factors for good and poor outcomes according to our experience in Kuwait after surgical clipping of ruptured subarachnoid hemorrhage. ICU: Intensive care unit, WFNS: World Federation of Neurosurgical Societies grading system

determine the outcome was for at least 6 months and was sufficient to decide the modified ranking score. The accuracy of data collection was completed in duplicate. In addition, a strict inclusion and exclusion criteria were applied for participant selection.

A major limitation is the retrospective design, creating a low possibility for imprecise data collection. However, the data were double-checked and revised to decrease the possibility of bias. This is an observational analysis, and there is still a chance of residual confounding. Another limitation is the relatively small sample size in relation to the long study duration.

CONCLUSION

There has been a considerable advance in microsurgical clipping experience in Kuwait. The recruitment of expertise, advancement of surgical techniques and intensive care, and the flow of cases have further improved our outcomes. We recommend considering the factors that we faced in our experience to optimize the management of SAH cases in neurosurgical centers. Larger multicenter studies to compare clipping and coiling outcomes are essential for better validation of both modalities in various centers.

Acknowledgment

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Declaration of patient consent

Institutional Review Board (IRB) permission obtained for the study.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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