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Original Article

Incidence, risk factors, and outcome of postoperative pneumonia after microsurgical clipping of ruptured intracranial aneurysms

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Abstract

Background: Occurrence of pneumonia challenges the medical management of patients who have undergone surgery for aneurysmal subarachnoid hemorrhage, and is associated with significant mortality and morbidity. There are very few studies evaluating the incidence and outcome of postoperative pneumonia in patients undergoing microsurgical clipping of ruptured intracranial aneurysms. The aim of this study was to determine the incidence, risk factors, and outcome of postoperative pneumonia in patients undergoing surgery for ruptured intracranial aneurysms.

Methods: All patients operated for intracranial aneurysms, over a period of 9 months, were included prospectively. They were studied for risk factors predisposing them to pneumonia and their outcomes were noted at discharge. Patients with predisposing chronic lung disease, preexisting pneumonia, and chronic smoking habits were excluded.

Results: One hundred and three patients [Mean age: 46.01 years; M:F – 58:45] underwent microsurgical clipping of aneurysm during the study period. Of these, 28 patients (27.2%) developed postoperative pneumonia. The variables associated with postoperative pneumonia were: [Preoperative] age >50 years, Glasgow Coma Scale (GCS) at presentation <15 and Hunt and Hess grade before surgery >2; [postoperative] duration of surgery >3 hours, GCS <15 after complete reversal from anesthesia, duration of intubation in the postoperative period >48 hours, tracheostomy, postoperative ventilation, intensive care unit (ICU) stay >5 days. Predictive factors for postoperative pneumonia by multivariate analysis were: Postoperative endotracheal intubation >48 hours, tracheostomy and ICU stay >5 days.

Conclusions: There is a high incidence of postoperative pneumonia and mortality associated with pneumonia (27.2% and 9.7%, respectively in our study) in patients of ruptured intracranial aneurysms undergoing microsurgical clipping at our center, with *Acinetobacter* species being the predominant causative organism.

Key Words: Chest infections, nosocomial pneumonia, outcome, ruptured intracranial aneurysms, risk factors

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INTRODUCTION

With advances in neuroimaging, micro-neurosurgery, and anesthesia techniques, the successful outcome in cases of aneurysmal subarachnoid hemorrhage (SAH) has improved. Occurrence of postoperative pneumonia in these patients challenges their medical management and may cause considerable morbidity and mortality.[8,20]

Neurosurgical patients are especially prone to develop pneumonia due to micro- and macro-aspirations and postoperative pneumonia commonly occurs in a significant proportion of all neurosurgery patients. Pulmonary complications are the most common medical causes of morbidity after SAH; nosocomial pneumonia being the most common among them.[8] It increases morbidity and mortality, prolongs hospital stay, and increases patient costs.[12]

There are no controlled studies available for incidence of postoperative pneumonia after aneurysmal surgery. The role played by this factor in the outcome of aneurysmal surgery is not well documented. Knowing the risk factors associated with chest infection could allow us to institute preventive measures in order to decrease the associated morbidity and mortality.[19]

The aim of our prospective study was to determine the incidence, risk factors, and outcome of postoperative pneumonia in patients undergoing surgery for ruptured intracranial aneurysms.

MATERIALS AND METHODS

Study design and patient population

A prospective cohort study was conducted during a period of 8 months at the Postgraduate Institute of Medical Education and Research, Chandigarh, India. The study was approved by the Institutional Ethics Committee and an informed consent was taken from all patients or their next of kin as applicable.

Inclusion criteria

All patients who presented to our institute with aneurysmal SAH and underwent microsurgical clipping of a ruptured intracranial aneurysm under general anesthesia during the study period were included.

Exclusion criteria

Patients with chronic lung disease, preexisting pneumonia, and chronic smoking habits (smoking index >100) were excluded.

Preoperative assessment

All patients included in the study were assessed in the neurosurgical emergency unit of our institute. The patients' Glasgow Coma Scale (GCS) score, Hunt and Hess Grade, Fisher grade, and co-morbid illnesses harbored by the patients were recorded after adequate resuscitation and hemodynamic stabilization. The Hunt and Hess grade was used in preoperative evaluation for the sake of uniformity, as it has been in use in our department for the past 20 years. The patients underwent a four vessel angiography, which revealed an aneurysm and were taken up for micro-surgical clipping on an emergency basis. The patients underwent a chest evaluation in the preoperative work-up, which included a chest radiograph.

Postoperative assessment

After the surgical procedure, the patients were transferred to the neurosurgical ICU or high dependency unit in the ward, depending upon the neurological status of the patient and the clinician's assessment, and followed daily from immediate postoperative period till hospital discharge or death. The patients' hydration status was monitored according to the intake/output charts. The patients in unconscious state, who required intravenous hydration, underwent insertion of a central venous catheter. The fluid used for intravenous hydration was normal saline and the central venous pressure was maintained at 8-10 cm of water.

Patients who remained on mechanical ventilation after surgery were placed on the volume-cycled synchronized intermittent mandatory ventilation mode under the guidance of an intensivist. Chest radiography was done in the immediate postoperative period and repeated whenever patients presented with changes on physical examination. On the day of onset of fever, complete hemogram, blood culture, sputum culture, and tracheal aspirate culture were sent for microbiological examination. The acute physiology and chronic health evaluation (APACHE II) score was recorded on the day of fever onset for each patient.

Patient information such as age and gender, duration of anesthesia (in hours), endotracheal tube (in hours), tracheostomy tube, mechanical ventilatory support (in hours), intensive care unit stay (in days), use of nasogastric tube for feeds and use of stress ulcer therapy were recorded. The severity of illness was assessed using the APACHE II score.

Patients with nosocomial pneumonia were empirically started on intravenous antibiotics after collection of the requisite cultures, and the antibiotics were modified depending upon microbiological antibiotic culture sensitivity. Outcome at discharge was assessed by Glasgow Outcome Score (GOS).

Outcome definitions

Nosocomial pneumonia was defined as the occurrence of new and persistent infiltrates on chest radiograph plus two of the following three: Fever >38°C, leukocytosis or leukopenia, and purulent tracheal aspirate. The diagnosis was subsequently confirmed with semi-quantitative

trachea-bronchial aspirates equivalent to counts of $\geq 10^5$ colony-forming units per milliliter (CFU/ml). Acute tracheobronchitis was defined by the presence of all the above criteria and a normal chest radiograph.

Statistical analysis

Data are presented in descriptive form either as mean (±SD) or median (interquartile range [IQR]) in normally distributed and skewed variables, respectively. Normality of data was checked using Kolmogorov–Smirnov tests. For normally distributed data, means were compared using unpaired Student's '*t*' test for two groups. For skewed data, Mann–Whitney test was applied. Qualitative or categorical variables were described as frequencies and proportions. Proportions were compared using chi square or Fisher's exact test whichever was applicable. Logistic regression analysis was performed to describe the variables associated with the occurrence of pneumonia. All statistical tests were two-sided and a probability value <0.05 was taken as significant.

RESULTS

In our study, 103 patients with aneurysmal SAH underwent craniotomy and microsurgical clipping of the ruptured aneurysm with Aesculap titanium clips, under general anesthesia. Table 1 shows the baseline characteristics of the patients. Twenty-eight patients (27.2%) developed postoperative pneumonia. Sixteen patients (15.5%) died; of these 16, 10 patients had postoperative pneumonia. The overall outcome of our study is depicted in Table 2. The microbiological evaluation of the patients with pneumonia revealed that *Acinetobacter* spp. was the dominant causative organism in 44.4% cases, followed by *Staphylococcus aureus* (26%), *Pseudomonas aeruginosa* (18.5%), and *Klebsiella* pneumonia (11.1%) [Table 3].

The variables studied for their association with postoperative pneumonia were: Age, sex, GCS and Hunt and Hess grade at presentation, preoperative GCS and Hunt and Hess grade, duration of surgery, postoperative GCS, duration of postoperative intubation, postoperative mechanical ventilation, ICU stay, tracheostomy, use of stress ulcer therapy and use of naso-gastric tube for feeds.

Univariate analysis showed that, out of the 14 variables studied, occurrence of postoperative pneumonia in surgically treated cases of ruptured intracranial aneurysms was associated with: Age >50 years, Hunt and Hess grade at surgery >2, postoperative GCS <15, duration of surgery >3 hours, duration of postoperative endotracheal intubation >48 hours, tracheostomy, postoperative mechanical ventilation, ICU stay (in days) >5 [Table 4].

Multivariate analysis, including all variables associated with postoperative pneumonia, using logistic regression analysis, demonstrated that the most predictive variables for the development of postoperative nosocomial pneumonia were: Duration of postoperative endotracheal intubation >48 hours, tracheostomy, and ICU stay (in days) >5 [Table 5].

Table 1: Demographic profile of patients and preoperative variables

Variables	Number (%)
Age (in years) [Mean (±SD)]	46.01±11.1
Sex [M:F]	58:45
Hunt and Hess grade	
I	20 (19.4)
II	52 (50.4)
III	26 (25.2)
IV	5 (4.8)
Preoperative GCS score	15 (IQR: 14-15)
Fisher grade	
I	22 (21.3)
II	43 (41.7)
III	28 (27.1)
IV	10 (9.7)

Column 2 showing numbers (%) unless specified GCS: Glasgow coma scale

Table 2: Overall outcome of the study group and outcome of patients with postoperative pneumonia

Outcome	All patients (103)	Patients with postoperative pneumonia (28)
Good outcome; GOS 4,5	75 (72.8)	9 (32.1)
Poor outcome; GOS 2,3	13 (12.6)	9 (32.1)
Mortality; GOS 1	15 (14.6)	10 (35.7)

Columns 2 and 3 showing numbers (%) unless specified

Table 3: Spectrum of tracheal culture growth in cases of postoperative pneumonia

Bacterial growth	Culture (+)	(%)
Acinetobacter spp.	12	44.4
Staphylococcus	7	26.0
Ps. aeruginosa	5	18.5
K. pneumoniae	3	11.1
Total	27	100

Table 4: Association between pre-and postoperative variables and the occurrence of postoperative pneumonia (by univariate analysis)

Factors	Odds ratio (OR)	(95% CI)
Age >50 yours	5.81	(2.2-14.9)
Hunt and Hess grade >2	3.4	(1.3-8.5)
Duration of surgery >3 hours	9.5	(2.6-34.27)
Postoperative GCS <15	6.5	(2.05-20.55)
Duration of postoperative ET >48 hours	25.1	(8.4-77.5)
Tracheostomy	95	(22.2-412.4)
Mechanical ventilation	69.43	(8.8-543.9)
ICU stay (in days) >5	72	(17.1-303.1)

GCS: Glasgow coma scale

Table 5: Multinomial logistic regression model for predictors of pneumonia showing the adjusted odds ratios after taking the factors that were nonpredictors as control

Predictors of pneumonia	Adjusted OR	95% CI	*P* value
ICU stay (in days) >5	9.8	(1.15-84.8)	0.036 (significant)
Tracheostomy	8.97	(0.97-80.8)	0.049 (significant)
Duration of postoperative ET >48 hours	6.638	(1.08-40.8)	0.041 (significant)
Postoperative GCS <15	2.731	(0.036-9.49)	0.479
Hunt and Hess grade >2	1.769	(0.289-10.81)	0.537
Duration of surgery >3 hours	0.584	(0.169-44.04)	0.705
Age >50 yours	0.252	(0.043-1.466)	0.125
Mechanical ventilation	0.152	(0.006-4.106)	0.263

GCS: Glasgow coma scale, ICU: Intensive care unit

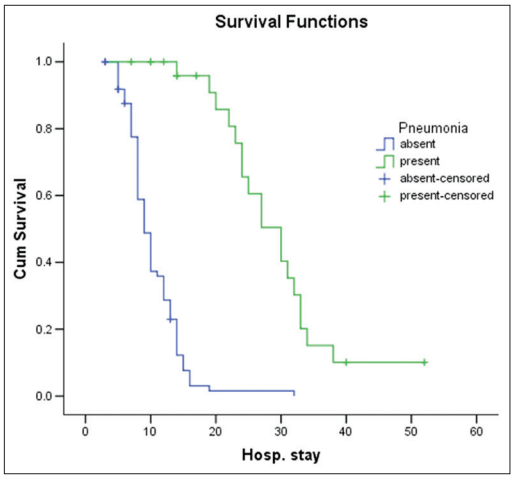

Figure 1: The Kaplan–Meier survival analysis comparing the hospital stay in two groups (Pneumonia vs. No pneumonia)

Kaplan–Meier survival curves were constructed to compare the hospital stay in patients with pneumonia vs. those without [Figure 1]. The median (95% CI) hospital stay was 9 days (7.9-10.1) in patients without pneumonia, whereas patients with pneumonia had a median (95% CI) hospital stay of 30 days (24.76-35.24), and the difference between the two groups was statistically significant.

DISCUSSION

In addition to the direct effects of the initial hemorrhage and secondary neurological complications, SAH predisposes to medical complications that have an impact on outcome.[21] Reduction of medical morbidity after SAH is an important potential means of improving overall patient outcomes. Pulmonary complications, including tracheobronchitis and pneumonia, are among the most common causes of morbidity after SAH.[8,11,13,15,19] Although neurosurgery itself is a strong risk factor for postoperative pulmonary complications (PPCs) like pneumonia, the predictive risk factors associated with such complications in neurosurgical patients are not specified.[18]

In the present study, 103 patients operated for micro-surgical clipping of aneurysm were evaluated for postoperative pneumonia. Chronic lung disease has been identified as a high risk factor for postoperative pneumonia in neurosurgical case series as well as in series involving other surgical sites.[19] Hence, patients with documented chronic lung disease were excluded from our study. The incidence of postoperative pneumonia and mortality associated with pneumonia were 27.2% and 9.7%, respectively. The most common causative micro-organism isolated from tracheal culture aspirates of patients diagnosed to have postoperative pneumonia was *Acinetobacter baumannii* (44.4%). In our multivariate analysis, the predictive variables for the development of postoperative pneumonia were duration of postoperative endotracheal intubation >48 hours, tracheostomy, and ICU stay >5 days.

The frequency of pulmonary complications among surgical and nonsurgical neurological patients varies widely, from 2.5% to 37%; probably due to the different settings and conditions in which surgeries are preformed, the clinical conditions of patients at the time of surgery, the pre- and postoperative care given to patients, and the definitions adopted for pulmonary complications.[2,3,16,19]

The results of our study demonstrate a high incidence of infectious pulmonary complications. The patients included in our study had aneurysmal SAH and were taken up for surgery on an emergency basis. This could be one of the factors that may have played a role in the high incidence of infectious complications in our study.

In a study of 236 patients undergoing elective intracranial surgery by Sogame, *et al.*, the incidence of PPC and mortality were 24.6% and 10%, respectively.[19] The most frequent PPCs were chest infections in the form of tracheobronchitis and pneumonia, seen in 22% patients. Chronic lung disease and duration of surgery ≥300 minutes were independent risk factors for PPC.

In a study by Freidman, *et al.*, pulmonary complications were documented in 66 (22%) out of 305 consecutive patients of aneurysmal SAH.[8] Pneumonia was found in 43 patients (15%). Although the overall clinical outcomes were worse in patients with pulmonary complications, pulmonary complications were not an independent predictor of worse outcome.

The most common organism isolated in the patients of postoperative pneumonia was the *Acinetobacter* species (44.4%), followed by *P. aeruginosa* (18.5%). This

is in accordance with other series that show that the incidence and prevalence of infection caused by these resistant pathogens is on the rise.[1,22] Although antibiotic stewardship and hand-washing are strictly being instituted in our ICU; they not only need universal compliance but are also clearly inadequate.

The influence of age on incidence of postoperative pneumonia is not well established. Increased risk of infection in patients over 60 years may be attributed to low immunity, poor physiological status, and higher incidence of co-morbid illness.[12] In our study, univariate analysis showed age more than 50 years as a statistically significant contributing factor to postoperative pneumonia, but in multivariate logistic regression analysis, age was not a significant factor.

Depressed level of consciousness causes loss of protective pharyngeal reflexes, with poor tussive capacity leading to aspiration and inability to breathe deeply; with subsequent increased risk of retention of secretions, prolonged intubation, impaired mucociliary clearance, and oral, pharyngeal, and gastric colonization.[17] Intuitively, altered sensorium is a contributing risk factor to postoperative pneumonia.[5] In our study, univariate analysis showed postoperative GCS <15 was associated with higher incidence of postoperative pneumonia, however, multivariate analyses did not find it as a predictive factor.

An increase in surgical time probably induces postoperative pneumonia as anesthetic agents can trigger alterations in diaphragmatic function, leading to increased mismatch of ventilation/perfusion ratios and interference with pulmonary defense mechanisms.[6,9] In this study, patients having duration of surgery greater than 3 hours had 9.5 times higher risk of developing pneumonia on a univariate analysis, however, this finding was not significant on multivariate analysis.

Patients requiring endotracheal intubation for more than 48 hours were 40 times more likely to develop postoperative pneumonia as compared with patients who were extubated within the first 48 hours of surgery, and this was further corroborated on a multivariate analysis. Endotracheal tube provides a surface for the formation of biofilm, which plays an important role as a reservoir for infecting micro-organism.[7] Fragments of biofilm may be dislodged and carried into the lung during ventilation. This may contribute to the increased incidence of pneumonia in patients requiring prolonged intubation. Mechanical ventilation for more than 48 hours has been documented as a risk factor for postoperative pneumonia as well as occurrence of death.[4]

In multivariate analysis, tracheostomy was an independent risk factor for development of postoperative pneumonia. Recent studies have reported high pneumonia rate (25%) after surgical tracheostomy.[10] In our study, 31 of the 103 operated patients were tracheostomized. Tracheostomy benefits patients receiving mechanical ventilation by facilitating nursing care, improving comfort and mobility by providing secure airway, allowing oral nutrition and facilitating weaning from mechanical ventilation. Normal closure of vocal cords reduces the risk of aspiration of secretions and decreases the duration of mechanical ventilation and ICU stay in early tracheostomized patients (tracheostomy done before 48 hours).[14] We follow the practice of early tracheostomy in our ICU, for patients requiring prolonged ventilation so that we may provide them the benefits of early tracheostomy as outlined above. Out of the 31 patients who were tracheostomized, 25 (81%) patients developed postoperative pneumonia. This incidence is high as compared to the one documented in literature. The reasons could be multifactorial considering that the patients requiring tracheostomy for a secure airway were those who had a stormy course in the postoperative period.

Our findings indicate that postoperative pneumonia was a common finding following neurosurgery for ruptured intracranial aneurysms. Those patients who developed postoperative pneumonia had mean hospital stay in days of 30 (±10) and ICU stay of 10 (±4), whereas those without infection had 9 (±4) and 3 (±3), respectively. This difference was statistically significant. This increases the cost of treatment both for the patients (longer hospital stay, ICU stay, antibiotics) as well as the health care system. Therefore, postoperative pneumonia should be considered an important factor affecting the morbidity, mortality, and cost of care in patients undergoing neurosurgery for ruptured intracranial aneurysms and strategies need to be implemented keeping this factor in mind.

CONCLUSIONS

There is a high incidence of postoperative pneumonia in patients undergoing microsurgical clipping of aneurysms following aneurysmal SAH. This calls for more effective respiratory care strategies in such patients. Further prospective studies with a larger patient population would be required to substantiate our results.

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