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INCIDENCE AND RISK FACTORS OF POSTOPERATIVE PULMONARY COMPLICATIONS IN PATIENTS UNDERGOING ELECTIVE CRANIOTOMIES

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Abstract:

Background: Pulmonary complications have detrimental effect on the disease progression leading to increased hospitalization, postoperative morbidity and mortality. **Aim:** To find the incidence of postoperative pulmonary complications in patients undergoing elective intracranial surgery. **Methods:** This Prospective observational study was conducted from 2020- 2022 in Superspeciality hospital, Shireen Bagh, Srinagar over a period of 18 months after approval by Institutional Ethical Committee. All patients underwent questionnaire about the preoperative data including Age, Sex, Weight, ASA physical state, History of smoking, Obstructive sleep apnea and Snoring. All the intracranial procedures were performed under general anaesthesia. After the surgical procedure patients were shifted to Superspeciality ICU and were followed daily from immediate postoperative period

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until a new surgical intervention, hospital discharge or death. **Results:** Out of 132 study patients, 79 (59.8%) were diagnosed with Meningioma, 18 (13.6%) patients Glioma, 17 (12.9%) with Pituitary Macroadenoma, 6 (4.5%) with CP Angle Tumor, 5 (3.8%) with Medulloblastoma, 4 (3%) with Posterior Fossa Tumor and 3 (2.3%) with Astrocytoma. Postoperative Pulmonary Complications were observed in 31 (23.5%) patients. Most common complication was found out to be Atelectasis (17.4%) followed by Tracheobronchitis (6.8%) followed by Pneumonia (6.1%), followed by ARDS (4.5%) and Weaning Failure in 6 (4.5%) study participants. Total number of postoperative pulmonary complications observed were 52. the mean duration of stay in ICU of patients who had POPCs was much higher (4.65 days) as compared to those who did not have POPCs (1.83 days). **Conclusion:** In our study, given a modest sample size, the incidence of POPCS in patients undergoing elective craniotomies was 23.5% and we were able to identify certain risk factors of POPC in our population, however more replicative studies with a larger sample size are warranted to substantiate these findings so that future preventive strategies can be formulated.

Keywords: Pulmonary complications, Intracranial procedures, ICU, General anaesthesia, Mortality.

Introduction:

Pulmonary complications are the second most prevalent significant morbidity after cardiovascular complications, accounting for one in four fatalities that occur within a week of surgery .[1] In addition, compared to 0.2–3% of patients without a POPC, one in five patients (14–30%) with a POPC will die within 30 days of major surgery. Thus, increasing mortality in both long & short term in the patients.[2-7]

On an average, >230 million major surgeries are done every year 2 and postoperative pulmonary problems can occur in a range of 21-23% in those major surgeries. [8-11]

Following some types of surgery, patients are at a significant risk of developing POPCs. [12,13] It has been observed that following abdominal aortic aneurysm repair, thoracic upper abdominal, or neck surgery, neurosurgery, and major vascular surgery, the risk of pneumonia is much higher. The likelihood of developing POPCs following abdominal and vascular surgeries has frequently been demonstrated. [14]

The occurrence of postoperative pulmonary problems is known to be significantly increased by neurosurgical procedures, including craniotomies. Reduced lung capacities and altered breathing patterns following intracranial

surgeries are likely contributing factors to the increased likelihood of postoperative pulmonary problems in neurosurgeries.[15]

General anaesthesia disturbs many aspects of respiratory function, and thus the incidence of POPCs is reduced in patients who have central or peripheral regional anaesthesia (RA) as compared to GA. Studies have shown that even for the same procedure, GA is an independent risk factor for POPCs compared with RA. Changes in the respiratory system occur immediately after general anaesthesia is administered; respiratory drive and muscle function are altered, lung volumes are reduced, and atelectasis develops in more than 70% of patients receiving a neuromuscular blocking drug. Following general anaesthesia for major surgery, the respiratory system may take up to 6 weeks to recover to its preoperative state.

Effort-dependent lung function tests, such as FVC, FEV1, and peak expiratory flow rate, are all significantly reduced following surgery, especially if the patient is in pain. [16] After major surgery, most respiratory muscle groups, including the airway muscles, abdominal muscles, and diaphragm, lose their normal activity.[17]

Anesthetics and NMBDs, postoperative analgesic medications (especially opioids), discomfort, disrupted sleep habits, and the inflammatory response to surgery are all factors that contribute to this dysfunction. The pathogenesis is more complicated than just simple muscle weakness; it also includes poor coordination between muscle groups, failure of typical physiological reflexes, and failure of the control mechanisms that normally regulate their activity.

Methods:

This prospective observational study "incidence and risk factors of postoperative pulmonary complications in elective craniotomies was conducted from 2020- 2022 in Superspeciality hospital, Shireen Bagh, Srinagar over a period of 18 months after approval by Institutional Ethical Committee.

Informed written consent was taken from the patients who underwent elective craniotomies (intracranial procedures) from age group 18-82 years and ASA class status 2nd and 3rd.

Inclusion Criteria:

1) Patients undergoing elective craniotomies under General anaesthesia.

2) Patients who are willing to participate and provide a willing written informed consent.

3) Patients 18-82 years.

Exclusion Criteria:

1) Emergency neurosurgery patients.
2) Intraoperative deaths.
3) Any surgical re-intervention.
4) Patients on preoperative mechanical ventilation.

All patients underwent questionnaire about the preoperative data including

- Age
- Sex
- Weight
- ASA physical state
- History of smoking
- Obstructive sleep apnea
- Snoring Other co-morbid illness
- Type and location of brain tumor (lesion)
- Preoperative respiratory status, level of consciousness and routine laboratory investigations
- Finding of preoperative X ray chest and CT MRI scan with respect to site and stage of lesion was noted.

All the intracranial procedures were performed under general anaesthesia. After the surgical procedure patients were shifted to Superspeciality ICU and were followed daily from immediate postoperative period until a new surgical intervention, hospital discharge or death.

Patients who remain on mechanical ventilation after surgery were placed on the volume cyclic SIMV mode with the following settings: TV= 6-8ml/kg, FiO2= to maintain SpO2> 94%, PEEP= 5cmH2O, RR between 12-16 beats/ min to maintain PCO_2 35-40 mmHg. Mechanical ventilation was managed by anesthetist in ICU. The process and decision of extubation was taken by anesthetist and neurosurgeon.

Outcome Definitions:

POPCs were defined as follows-

1) ***Atelectasis*:** Defined as lobar collapse on chest X ray.

2) ***Pneumonia***: Diagnosis of pneumonia was made if pulmonary infiltrates were present on chest X ray along with purulent tracheobronchial secretion, elevation of body temperature >38.3 C and abnormal leucocyte count <4000 or >12000.

3) ***Tracheobronchitis*:** Increase in quantity or change in the colour of sputum or purulent aspect of tracheobronchial secretion with normal chest X ray.

4) *ARDS/ARF*: It was considered if mechanical ventilation were initiated in view of

respiratory distress with low P:F ratio on ABGs.

5) ***Weaning Failure*:** It is defined as need for reintubation within 24 hours of extubation.

Statistical Analysis

The data was entered in a Microsoft Excel spreadsheet. Continuous variables were summarized as mean and SD. Continuous variables with a non-normal distribution were summarized as median and interquartile range. Categorical variables were summarized as percentages. Chi-square test was used to analyze the relationship between 2 categorical variables. Unpaired t-test was used to analyze the difference between 2 means. To analyze the difference in the distribution of non-normally distributed continuous variables/discrete variables across 2 groups, Mann-Whitney test was used. Incidence of postoperative pulmonary complications was calculated as an incidence proportion and reported along with 95% confidence interval. The relative risk of postoperative pulmonary complications was reported for defined risk factors and reported along with its 95% CI. Data analysis was done using stata 15.0. $p<0.05$ was considered statistically significant.

Results:

The age of study participants varied from 18 (minimum age) to 82 (maximum age) years with mean age of distribution 42.30±17.08 years. 68 (51.5%) were females and 64 (48.5%) were males. Out of 132 study patients, 79 (59.8%) were diagnosed with Meningioma, 18 (13.6%) patients Glioma, 17 (12.9%) with Pituitary Macroadenoma, 6 (4.5%) with CP Angle Tumor, 5 (3.8%) with Medulloblastoma, 4 (3%) with Posterior Fossa Tumor and 3 (2.3%) with Astrocytoma [Table 1].

Table.1: Distribution of study participants according to diagnosis.

Diagnosis	Frequency	%
Meningioma	**79**	**59.8**
Glioma	**18**	**13.6**
Astrocytoma	**3**	**2.3**
Medulloblastoma	**5**	**3.8**
Pituitary Macroadenoma	**17**	**12.9**
Cp Angle Tumor	**6**	**4.5**
Posterior Fossa Tumor	**4**	**3.0**

COPD was found in 33 (25%) patients followed by hypertension in 32 (24.2%) patients followed by presence of smoking in 25 (18.9%) followed by T2DM in 16 (12.1%) patients [Table 2].

Table.2: Distribution of various co-morbidities among study participants.

Characteristic	Status	Frequency	%
Hypertension	**Absent**	**100**	**75.8**
	present	**32**	**24.2**
T2DM	**Absent**	**116**	**87.9**
	present	**16**	**12.1**
COPD	**Absent**	**99**	**75.0**
	present	**33**	**25.0**
Smoking	**Absent**	**107**	**81.1**
	present	**25**	**18.9**

Postoperative Pulmonary Complications were observed in 31 (23.5%) patients. Most common complication was found out to be Atelectasis (17.4%) followed by Tracheobronchitis (6.8%) followed by Pneumonia (6.1%), followed by ARDS (4.5%) and Weaning Failure in 6 (4.5%) study participants. Total number of postoperative pulmonary complications observed were 52, suggesting presence of more than one complication in some of our study participants [Table 3].

Table.3: Distribution of Postoperative Pulmonary Complications among the study participants.

Characteristic	Status	Frequency	%
Postoperative Pulmonary Complications	**Absent**	**101**	**76.5**
	present	**31**	**23.5**
Atelectasis	**Absent**	**109**	**82.6**
	present	**23**	**17.4**
Tracheobronchitis	**Absent**	**123**	**93.2**
	present	**9**	**6.8**
Pneumonia	**Absent**	**124**	**93.9**
	present	**8**	**6.1**
Ards/ARDS	**Absent**	**126**	**95.5**
	present	**6**	**4.5**
Weaning Failure	**Absent**	**126**	**95.5**
	present	**6**	**4.5**

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Maximum postoperative pulmonary complications were observed in patients with posterior fossa tumor (50%) followed by Glioma (44.4%) which was followed by Meningioma (26.6%). This difference in incidence of Postoperative pulmonary complications in patients with different diagnosis was statistically significant with p value of 0.01[Fig 1].

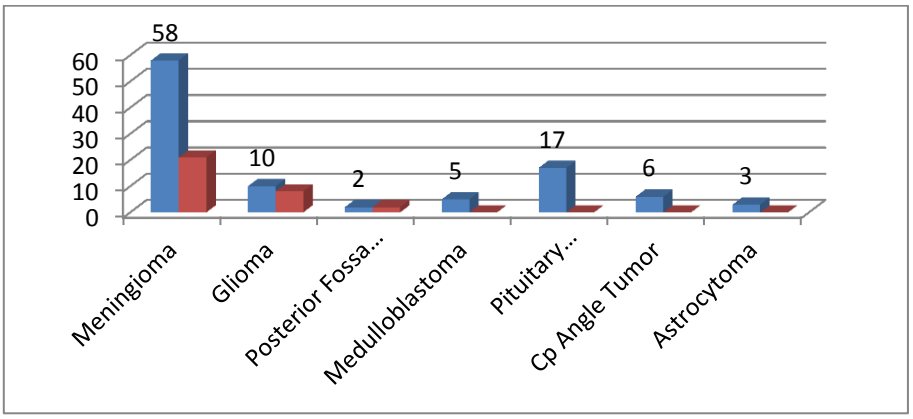

Fig 1 depicting relationship between Diagnosis of patients and Postoperative Pulmonary Complications.

Mean age of patients who had POPCs was much higher (56.03 years) as compared to those who did not have POPCs (38.08 years). This mean difference in age around 18 years was statistically significant [Fig 2].

The mean duration of intubation of patients who had POPCs was much higher (17.18 hours) as compared to those who did not have POPCs (8.19 hours). This mean difference in duration of intubation around 9 hours was statistically significant [Fig 3].

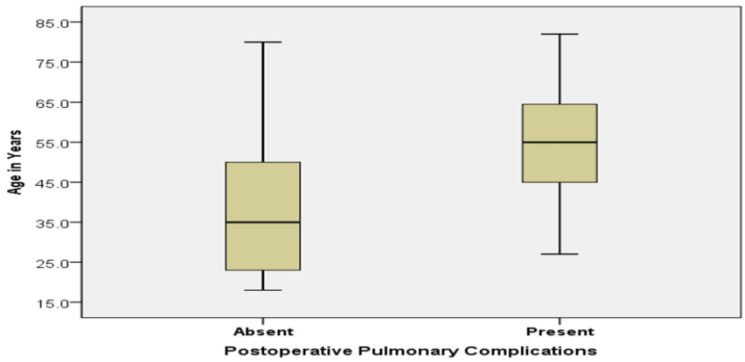

Fig 2

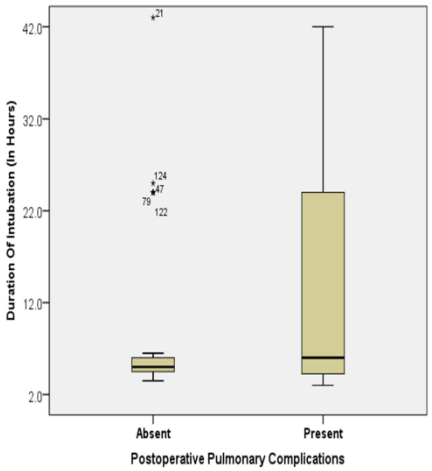

Fig 3

Discussion:

Postoperative pulmonary complications are the occurrence of postoperative abnormal lung manifestations like atelectasis, pneumonia, tracheobronchitis, ARDS, acute respiratory failure and weaning failure. These complications have an adverse impact on the course of the disease, necessitating lengthier hospital stays for patients and raising the postoperative death rates. A clinically significant and recognizable pulmonary change, that has a negative postoperative impact on the patient's prognosis, is referred to as a postoperative pulmonary complication (POPC) .[18] The reported incidence of POPC in individuals undergoing general surgery varies greatly.[19] Most studies define POPCs as postsurgical patients who have atelectasis, pneumonia, pulmonary oedema, aggravation of existing chronic lung disease, or respiratory failure.[20,21]

There is a substantial risk of POPCs following neurosurgical operations .[22] A probable reason for the elevated risk is the post-craniotomy decrease in lung volumes and arterial blood gas tensions, together with the corresponding alteration in breathing rhythm [23]and various other factors such as mechanical obstruction, central respiratory dysfunction, and neuromuscular dysfunction which interact with one another after intracranial surgeries. These patients are at significant risk of developing POPCs after craniotomies because of the many cardiopulmonary changes that are associated with it. The POPCs in individuals who had elective craniotomies, however, have not received much research. Because of this, we conducted this study to determine the incidence of POPCs and related risk factors in patients who have undergone elective craniotomies. Additionally, the effect of POPCs on the duration of stay and neurological outcome was investigated.

In our study, the mean age of the patients enrolled was 42.30 (±17.08) years, ranging between 18 to 82 years. In our study, we observed that meningioma was the

most common (~60%) diagnosis followed by Glioma (~14%). Meningiomas are benign neoplasms that arise from the dural layers covering the brain and spinal cord. They account for up to 30% of all primary intracranial tumors and typically are slow growing . We found that 18(13.6%) had pituitary macroadenoma, 6 (4.5%) had CP Angle tumors, 5 (3.8%) had medulloblastomas, 4 (3%) had posterior fossa tumors, and 3 (2.3%) had astrocytoma.

In our study, female patients were more (52%) than male patients (48%). However, we observed that males (29.7%) had a greater incidence of POPC than females (17.6%). The frequency of postoperative pulmonary disease varied by gender, although it was not statistically significant. Unlike our results, two independent studies by **Hooda et al**, in patients who underwent craniotomy and excision of posterior fossa tumor[24] and **Chu et al** in patients who underwent elective craniotomy for tumors of the brainstem or adjacent to the brainstem[25] reported an overrepresentation of females. Even though a random selection of cases was performed, however, in absence of any anatomical differences in the skull structures of males and females it remains to be studied how gender can determine the susceptibility to any post-operative complications. No convincing mechanisms or pathophysiological explanations have been offered so far for these gender-based differences. The confinement of females to their homes, exposure to indoor infectious agents, and subsequent late presentation to the tertiary health care facilities in our population cannot be entirely ruled out.

Out of 132 patients enrolled in our study, ~25% were found to have Chronic obstructive pulmonary disease (COPD), 24.2% were hypertensive, ~19% were smokers, and 12.1% had T2DM. COPD affects a large section of the whole population and is also one of the risk factors of POPCs in the perioperative setting .[26] Moreover, impaired pulmonary function, which is a remarkable manifestation of COPD, is also one of the risk factors of POPCs .[21,27,28] However, the earlier study conducted by **Hooda et al.,** and **Chu et al.,[24,25]** did not report any subject with any of these co-morbidities. Findings from Chinese populations have reported that COPD affected 13.7% of people over 40 years of age and results in a hospital stay rate of 1.6% in 2015.[29,30] Studies have confirmed that the introduction of COPD treatment can reduce the risk of POPCs[87]. On the other hand, POPCs and their treatment can alter the disease course significantly in COPD patients. [21,27, 28, 31]

Upon assessing the correlation of different co-morbidities with the POPC we did not find any correlation between underlying hypertension and T2DM with POPCs. However, a positive correlation between the development of POPCs with COPD and smoking was observed ($p<0.001$). COPD is prevalent in the general population, therefore can modulate the risk of PPCs in the pre and postoperative setting.[26] Moreover, it has been reported that impaired pulmonary function, which is a remarkable manifestation of COPD, is also one of the risk factors for POPCs .[21,27,28] Similar to

our results, **Sogame et al.,** have also found a strong association between postoperative pulmonary complications in elective intracranial surgery in patients with COPD .[32] Moreover, the evidence of postoperative complications associated with smoking has varied significantly and the results are missed and inconclusive. Based on the data from 8296 patients who underwent elective cranial surgery, **Alan et al**., did not find smoking to be associated with 30-day postoperative morbidity or mortality .[33] However, similar to our results, a recent large retrospective cohort analysis based on 800 Korean patients found significant associations between smoking status and postoperative pulmonary complications .[34] In patients undergoing a variety of non-neurosurgical operations, smoking has been identified as an independent risk factor for poor operative outcomes. In patients undergoing craniotomy for tumor resection, **Lau et al.,** reported that smoking increased the risk for morbidity and the 1-year mortality rate .[35] Even if smoking itself does not exert an independent effect on postoperative outcomes, one might expect its associated comorbidities to influence the morbidity or mortality levels after major operations such as cranial surgery .[33]

Neurosurgical treatments such as craniotomy have been described as substantial risk factors for the development of pulmonary complications. Recently **Hooda et al.,** observed that Infratentorial neurosurgery operations are deemed high risk for the development of POPCs, lengthening the hospital stay of patients with severe morbidity and death .[24] Following infratentorial tumour surgery, they identified a 12% incidence of POPC, with postoperative blood transfusion, lower cranial nerve palsy, a longer stay in the intensive care unit, and tracheostomy being predictors.[24] In patients who underwent craniotomies for tumour removal, **Sawaya and colleagues** observed a low incidence of pneumonia (2.5%), a pulmonary complication; nevertheless, the majority of the patients received an antibiotic as a preventative precaution before the surgical surgery .[36]

In our study, POPC was noted in 23.5% of the patients. Atelectasis (17%) was reported to be the most frequent consequence, followed by tracheobronchitis (~7%), pneumonia (6%), ARDS, and weaning failure in 6 (4.5%) study patients. In aggregation, 52 subjects reported postoperative pulmonary complications, suggesting some of the patients experienced more than one complication. Most of the participants (89%) had their intraoperative period uneventful, whereas 14 patients (11%) had eventful Intraoperative (hemodynamic instability, any MACE) period. In our investigation, it was observed that study participants with an eventful intraoperative period had 64.3% more postoperative pulmonary problems than study participants with an uneventful intraoperative period (18.6% more). Unlike our results, **Hooda et al.,[24]** reported a low prevalence of POPCs in their study and **Chu et al** found Pneumonia in 12% of subjects .[25] The difference can be attributed to the differences in the sample sizes used by these different studies and warrants further investigation to have a clearer picture of

POPC in elective craniotomies.

In the current study, patients with posterior fossa tumors experienced the highest rate of postoperative pulmonary problems (50%) followed by gliomas (44.4%), which were then followed by meningiomas (26.6%). A statistically significant variation in POPC incidence across individuals with various diagnoses was observed. However, in a similar study by **Hooda et al.,** the prevalence of POPCs was reported 12.1% in patients who underwent craniotomy and excision of posterior fossa tumor in their study .[24]

Respiratory depression, reintubation, bronchospasm, laryngospasm, and upper airway obstruction are among the early reports of respiratory difficulties in patients receiving elective neurosurgery operations. These issues affected 2.8% of patients . [37] Sogame conducted a prospective evaluation of 236 neurosurgical patients and found that 58 patients (24.6%) had POPCs as a result of tracheobronchitis (32), pneumonia (20), bronchospasm (19), and atelectasis (5) .[38] According to **Sogame et al.,** there was a 25% incidence of POPCs and a 10% death rate among individuals who had elective craniotomies. The kind of surgery, lengthy mechanical ventilation (>48 hours), lengthier stay in the intensive care unit (>3 days), lower state of awareness, length of operation (300 minutes), and history of chronic lung illness were the risk variables identified.

In our study we found that the mean duration of surgery in patients who had POPCs was 4.95 hours as compared to those who did not have POPCs (4.80). This difference in duration of surgery was statistically insignificant. Patients with POPCs had significantly longer average intubation times (17.18 hours) than those without POPCs (8.19 hours).

In terms of morbidity, mortality, extended hospital stays, and increased healthcare costs, pulmonary dysfunction during the postoperative period is a significant burden .[39] Patients with POPCs in our study had considerably longer stays in the ICU and hospitals. Additionally, a separate association between POPCs and ICU stays longer than 3 days was discovered. In our study, patients with POPCs had significantly longer median ICU stays (4.65 days) than patients without POPCs (1.83 days). These results concur with those of earlier research on individuals undergoing neurosurgery. [40,41]

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