Smoking and Obesity are Risk Factors for Thirty-Day Readmissions Following Skull Base Surgery

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Abstract

Background Thirty-day readmission has become a significant health care metric reflecting the quality of care and on the cost of service delivery. There is little data on the impact of complications following skull base surgery (SBS) on emergency readmission. Identifying modifiable risk factors for readmission may improve care and reduce cost.

Design The study was designed as a single-center retrospective cohort study.

Methods Records for a consecutive series of 165 patients who underwent open or endoscopic SBS by a single surgeon reviewed. Patients with pituitary adenoma were excluded. The diagnosis, procedure, complications, length of stay (LOS), body mass index (BMI), and smoking status were recorded. Readmission to the neurosurgical department or regional hospitals was either noted prospectively or the patient contacted. Cause and length of readmission was documented.

Results Of the 165 cases, 14 (8.5%) were readmitted within 30 days. Causes for readmission included cerebrospinal fluid (CSF) leak in 5/14 or 35.7% (overall rate for readmission for this complication in the series is 3.1%), infection in 4/14 (28.6%), hyponatraemia in 2/14 (14.3%), vascular: sinus thrombosis in 1/14 (7.1%), seizures in 1/14 (7.1%), and epistaxis in 1/14 (7.1%). Initial and readmission LOS was 6 and 14 days, respectively. BMI was higher in those readmitted within 30 days (33.2 kg/m^2) versus no readmission (27.1 kg/m^2). In addition, of those readmitted within 30 days, 35.7% were smokers compared with 20.8% in those not readmitted.

Conclusion In this series, smoking and raised BMI may be indicators for within 30-day readmission and complications in this population, raising the question of risk factor modification prior to elective intervention.

Keywords
- skull base
- 30-day readmission
- smoking
- obesity

Introduction

Postsurgical readmissions are common and vary by procedure.[1–3] They are significant drivers for increased expenditure in health care and both the Department of Health in the United Kingdom and Medicare and Medicaid in the U.S.A. have produced guidance and financial penalties for unplanned readmissions.[4,5]

Unplanned readmissions within 30 days of the index procedure has now become a significant health care metric

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reflecting both quality of care and cost of service delivery[6] and the U.K. Society for British Neurological Surgeons have adopted 30-day readmissions as a marker of quality of care.[7] Interventions aimed at reducing all cause 30-day readmissions has been well documented in a recent metanalysis.[8] In an effort to reduce 30-day readmissions, health care policy has begun to focus on identifying the causes of unplanned readmissions for all types of procedures.[6] Several studies have looked at patient comorbidities in an attempt to identify modifiable risk factors[9–11] however, no single intervention or multicomponent intervention implemented was regularly associated with reduced risk for 30-day rehospitalization.

In neurosurgery, unplanned readmissions have been documented for spinal[12–15] and cranial[16–23] procedures. While these studies have provided a broad overview for postsurgical readmission, causes for readmission following more specialized procedures in neurosurgery has not been well documented. Skull base surgery carries a high risk for common complications, such as infection and cerebrospinal fluid (CSF) leak.[24–28] Unplanned readmission following endoscopic transphenoidal surgery for pituitary tumors has recently been reported[29] however, there is currently little data looking at what drives readmission following different types of skull base surgery (SBS). Identifying modifiable risk factors, such as comorbidity, smoking history, and body mass index (BMI) in patients who have undergone SBS that could contribute to the risk of postsurgical readmission may reduce cost to national health care bodies and may improve patient outcomes and overall care.

The aim of this retrospective study was to identify causes for readmission within 30 days of an index procedure and identify specific risk factors that could be driving complications following SBS resulting in unplanned readmission.

Methods

Patient Population

Medical records for 165 patients who underwent either an open or endoscopic skull base surgical procedure at our institution (University Hospital of Wales, Neurosurgery) between June 2011 and August 2017 were retrospectively reviewed to determine the cause, if any, of unplanned readmission within 30 days of surgery. Patients with pituitary adenoma were excluded from this study.

Data Collection

Records for the 165 consecutive patients were reviewed noting the demographics including age and sex. Original diagnosis on index admission including type of tumor and location, classified as anterior or lateral skull base. The procedure performed was also recorded including duration, whether any perioperative blood transfusion was required, intensive care unit (ITU) admissions postoperatively, whether it was open, endoscopic, or a combination of both.

We recorded the smoking status, BMI, and comorbidities including depression, anxiety, congestive cardiac failure, Ischemic heart disease, atrial fibrillation, myocardial infarction, diabetes, hypertension, hyperlipidaemia, chronic kidney disease, and gastro-oesophageal reflux disease. Postoperative variables were recorded including length of inpatient stay and immediate($<$ 24 hours), early($<$ 30 days), and late ($>$ 30 days) complications during the index admission. Complications were classified into groups to include: CSF leak, infection (localized wound and systemic meningitis), endocrine (including hyponatraemia and diabetes insipidus [DI]), vascular (infarct), pseudomeningocoele, and "other" (epistaxis, endonasal crusting).

For patients who were readmitted within 30 days of the index admission, the cause and length of readmission were documented along with LOS. Patients were contacted to establish whether they had been readmitted to other units within 30 days of their original procedure.

Data Analysis

Parametric and nonparametric data were expressed as median with range. Statistical analysis was performed using logistic regression with adjustment for key confounders. To incorporate time to readmission hazard ratios were performed with baseline time set at date of initial discharge. The threshold for a statistically significant difference was prespecified as a p value less than 0.05. All analyses were performed on STATA version 12 (StataCorp LLC).

Results

Demographics, Surgical Pathology, LOS, and Comorbidities

Between June 2011 and October 2017, a total of 165 patients underwent SBS for various pathologies. The most common indication for surgery in this series was for meningioma (33.3%) followed by acoustic neuroma (29.7%), craniopharyngioma (7.3%) and spontaneous CSF leak repair (6.1%). There were several other pathologies, these are summarized in ►**Table 1**.

►**Table 2** outlines the demographics for the patients studied. Within the total cohort, there was a 3:1 ratio for females to males; in all, there were 109 females (66.1%) and 56 males (33.9%). In patients who were readmitted within 30 days, a similar 3:1 ratio was maintained; there were nine females (64.3%) and five males (35.7%). The median age was similar between patients on initial admission and those readmitted within 30 days at 51.0 years (range, 5.0–79.0 years) versus 50.0 years (range. 36–63 years), respectively. Median LOS in days was 6.0 days (range, 3–56 days) in those not readmitted compared with 13.0 days (range, 358 days) in those readmitted. Median duration of surgery in hh:mm (range) was 5:15 (00:39–12:17) in patients not readmitted within 30 days versus 06:49 (02:11–11:53) in those readmitted. There was no discernible difference between common comorbidities in patients undergoing a primary procedure and in those representing within 30 days. None of the 165 patients operated had a perioperative blood transfusion. All patients were admitted to a neurosurgical high-dependency unit as is standard in our unit. Three (1.8%) patients were admitted to ITU, two for postoperative hypertensive management, and one for difficulty with extubation. LOS in ITU was 24 hours. These patients were not amongst those readmitted within 30 days.

Table 1 Surgical pathology

Pathologies no. (%)	Study cohort ($n = 165$)
Acoustic neuroma – Retrosigmoid – Translabarynthine	49 (29.7)
Meningioma – Retrosigmoid – Subfrontal – Sphenoid wing – Spheno-orbital – Middle fossa – Petroclival – Olfactory groove – Eyebrow – Foramen magnum – Parasellar – Tuberculum sella – Planum – Endonasal	55 (33.3)
Schwanomma – Glossopharyngeal – Trigeminal – Retrosigmoid	3 (1.8)
Epidermoid cyst – CP angle – Orbitozygomatic – Cavernous sinus	8 (4.8)
Dermoid cyst – Paradinoid	1 (0.61)
Pituitary adenoma – Endonasal – Transcranial	6 (3.6)
Hemifacial spasm	6 (3.6)
Glioma – CP angle – Optic nerve	2 (1.2)
Fibrous dysplasia – Spheno-orbital – Optic nerve	2 (1.2)
Craniopharyngioma – open – Endoscopic	12 (7.3)
Neurofibroma – Orbital	2 (1.2)
CSF leak repair – Transmastoid – Anterior fossa – Endoscopic	10 (6.1)
Odontoidectomy – Endoscopic	1 (0.61)
Anterior fossa aneurysmal bone cyst – Endoscopic	1 (0.61)
Clival tumor – Endoscopic	2 (1.2)
Chondrosarcoma–petrous apex	1 (0.61)
Lacrimal carcinoma	1 (0.61)
Infundibulum biopsy	1 (0.61)
Sinus carcinoma	1 (0.61)
Anterior skull base procedures	44 (26.7)
Lateral skull base procedures	89 (53.9)
Endoscopic procedures	32 (12.1)

Abbreviation: CP angle, cerebellopontine angle.

Table 2 Demographics, length of stay and comorbidities

Variables	Total cohort ($n = 165$)	30-day readmissions $n = 14$
Age–median (range)	51.0 (5.0–79.0)	50.0 (36.0–63.0)
Male no. (%)	56 (33.9)	5 (35.7)
Female no. (%)	109 (66.1)	9 (64.3)
Length of stay–median (range)	6.0 (3.0–56.0)	13.0 (3.0–58.0)
Median surgical time hh:mm (range)	05:15 (00:39–12:17)	06:49 (02:11–11:53)
Smoking status no. (%)[a]	20.8	35.7
Body mass index[b] (range)	27.4 (12.3–50.7)	33.8 (20.5–41.3)
Comorbidities		
Hypertension no. (%)	41 (24.8)	4 (28.6)
Type II diabetes mellitus no. (%)	13 (7.9)	2 (14.3)
Epilepsy no. (%)	6 (3.6)	0 (0)
Asthma no. (%)	14 (8.48)	2 (14.3)

[a]Data for smoking are missing for 21 patients.
[b]The body-mass index (BMI) is the weight in kilograms divided by the square of the height in meters. Data for BMI are missing for 35 number of patients.

However, two key modifiable risk factors, BMI and smoking, showed a clear difference between the two groups. First, we compared the mean BMI in kg/m^2 for patients not readmitted versus those patients readmitted within 30 days for complications. These showed a significant difference 27.4 kg/m^2 (range, 12.3–50.7 kg/m^2) versus 33.8 kg/m^2 (range, 20.5–41.3 kg/m^2). Logistic regression identified that obese people (BMI > 30) had increased odds ratio (OR) $= 6.99$ (95% confidence interval [CI]: 1.81–26.9), $p = 0.005$ of being readmitted within 30 days even after adjustment for age, sex, and smoking status. In keeping with this the hazard ratio for readmission in individuals with obesity after adjustment was 5.38 (95% CI: 1.62–17.9), $p = 0.006$. The relationship with obesity and readmission was largely driven by those with a BMI greater than 35; those with a BMI greater than 35 had substantially increased odds of readmission within 30 days OR $= 9.09$ (95% CI: 2.11–39.1), $p = 0.003$.

Second, we analyzed smoking status amongst the two groups. In those not readmitted, there were 30 (20.8%) smokers versus five (35.7%) that were readmitted within 30 days. The odds of being a smoker and being readmitted within 30 days with a complication was also raised (OR $= 3.31$; 95% CI: 1.05–10.4; $p = 0.04$).

Complications Resulting in 30-Day Readmission

A total of 14 (8.5%) patients were readmitted within 30 days of the index procedure (►**Supplementary Table 1**, online only). Readmission occurred between 1 and 24 days after initial discharge. Eleven of the 14 patients were readmitted back to the index hospital, three were seen at a local hospital

for management. The causes for readmission included CSF leak in 5/14 (35.7%), overall rate for this complication in the series is 3.1%. Infection in 4/14 (28.6%), hyponatraemia in 2/14 (14.3%), vascular sinus thrombosis in 1/14 (7.1%), seizures in 1/14 (7.1%), and epistaxis in 1/14 7.1%. Of these 14 readmissions, 5/14 (35.7%) were lateral skull base and 9 (64.3%) were anterior skull base. Of the anterior skull base readmissions, 2/9 (22.2%) were endoscopic procedures. These included 1/9 (11.1%) with epistaxis and 1/9 (11.1%) with sinus infection. There were no patients with CSF leak following endoscopic surgery.

Endoscopic versus Open Transcranial Approach

Of the 165 cases, 32 (19.3%) were performed by endoscopic approach (including resection of craniopharyngioma, meningioma, and sinonasal malignancy) and 133 patients had an open transcranial approach. We analyzed the data to look at whether there was a difference in complication rate for open versus endoscopic procedures. Fourteen patients (8.5%) were readmitted within 30 days of which 12 (7.2%) were following open transcranial approach and 2 (1.2%) following an endoscopic approach. Causes for readmission in those undergoing an open transcranial approach included CSF leak 5/12 (41.6%), infection 3/12 (25%), hyponatraemia 2/12 (16.7%), vascular 1/12 (8.3%), and seizures 1/12 (8.3%). In those undergoing an endoscopic approach, causes included sinus infection 1/2 (50%) and epistaxis 1/2 (50%). The median initial LOS was 6.0 days (range, 3–56 days) with open surgery and 6.0 days (range, 1–37 days) with the endoscopic approach. Of the patients who had an open transcranial approach and were readmitted within 30 days, 41.6% (5/12) were smokers. Conversely, in the endoscopic group 100% of the 30-day readmissions were smokers. After an endoscopic procedure, patients who were readmitted within 30 days had a raised BMI of 33.8 kg/m^2 (range, 20.2–50.7 kg/m^2) versus 28.1 kg/m^2 (range, 32.7–35.0 kg/m^2), although no CSF leaks were seen in the delayed setting. In those undergoing an open transcranial procedure, 30-day readmissions had a raised BMI of 33.7 versus 26.5 kg/m^2 in those not readmitted.

Discussion

Our series addressed an important contemporary aspect of health care–root analysis of unplanned readmission within 30 days of surgery and identifying modifiable risk factors to prevent readmission in the future. In this retrospective study, the key finding is that obesity (BMI $>$ 30 kg/m^2) and, to a lesser extent, smoking increases the risk of 30-day readmission following SBS.

The 30-day readmission rate for patients in this series was 8.5%. To our knowledge, there has not been a review of 30-day readmission rates following open skull base procedures. Previous reports have focused principally on endoscopic endonasal procedures, where intraoperative use of pedicled nasoseptal flaps was associated with successful repair of CSF leak and as a result lower 30-day readmissions.[30] There are several different series that report varying degrees of readmission rates following cranial surgery. Buchanan et al[19] performed a retrospective review of 5,569 patients who had undergone a cranial or spinal procedure and reported a readmission rate of 6.9%. Sughrue et al[31] performed a review of 313 patients who underwent surgery for an intra-axial tumor and reported a readmission rate of 4.2%. A large study by Moghavem et al,[20] performed a retrospective analysis of 43,356 patients who had an intracranial procedure, showing a readmission rate of 19.4%. The largest series to date is with 163,743 patients who had craniotomies, cranial surgery without craniotomy, spine, and neuroendovascular procedures demonstrated a 30-day readmission rate of 9.03%. The causes for these reported readmissions showed that 29.5% were related to infection, 19.2% medical complications, 8.7% new neurological signs or symptoms, 6.1% stroke, 5.7% venous thromboembolism, and CSF leaks accounting for less than 5%.[21] Our data, with a readmission rate of 8.5% appear to be in line with previously published 30-day readmission across neurosurgical procedures involving tumor resection.

Patient demographics and LOS was consistent with what has been previously published. Length of inpatient stay for index admissions in our series (6.0 days) was the similar to large series reported as between 5.0 and 10.0 days, whereas those for readmission (13.0 days in our series) tend to be longer in but are comparable with published data.[19,20,22] Several reports have suggested that initial length of inpatient stay at the index admission correlated with the rate of readmission,[17,18] so that longer initial LOS meant a reduced risk of readmission. We were unable to extrapolate these findings to our data as there was no significant difference between the median initial LOS for patients that were readmitted (7.0 days) compared with LOS (6.0 days) for patients not readmitted in our series. To our knowledge, no previous reports have looked at modifiable risk factors as a cause for readmission after SBS.

One discrepancy was that our data showed a higher number of females to males in a ratio of 3:1. This may be secondary to the large numbers of meningiomas and (33.3%). Females have an increased risk of meningioma by 2:1[32] and this could account for the larger numbers of females in this group.

Complications Resulting 30-Day Readmission

Fourteen patients were readmitted within 30 days secondary to a complication. These included CSF leak, infection, hyponatraemia, sinus thrombosis, epistaxis, and seizures. CSF leak remains a common complication following SBS and occurs frequently postoperatively[24–28] but is usually managed during the index admission. CSF leak post discharge from hospital puts the patient at risk of wound infection and meningitis. Our 30-day readmission patients who had a CSF leak was 35.7% which remains at the higher end of that reported in the literature. In the large series by Buchanan et al,[19] they had a 30-day readmission rate for CSF leak at 8.5%. This constitutes all cause cranial procedures and, therefore, not directly comparable with our series which encompasses skull base procedures alone with an inherently higher risk of CSF leak. Other reports focus primarily on CSF leak in endoscopic endonasal surgery such that Ivan et al[33] reported a CSF leak rate of 11% in

98 patients undergoing endoscopic endonasal procedures with a higher proportion of those leaks in patients with BMI > 30 kg/m^2. In addition, in a cohort of 92 patients undergoing endoscopic endonasal procedures, Dlouhy et al[34] reported a leak rate of 13.5% predominantly in those with an average BMI of 39.2 kg/m^2. In the five patients in our series who presented with a CSF leak postoperatively, three had a BMI greater than 30 kg/m^2 and all were open skull base procedures. Certainly, some case series suggest that BMI is an independent predictor of 30-day readmission following spinal[35] and cranial[36] surgery. Should we therefore anticipate a CSF leak in obese patients undergoing skull base procedures? Managing CSF leak has been controversial with some reports suggesting that prophylactic lumbar drains could be beneficial as an essential adjunct to primary layered closure following endonasal endoscopic procedures to prevent CSF leak, particularly in patients with high BMI.[37] However, the risks of lumbar drain placement include CNS infection, tension pneumocephalus, low pressure headache, and epidural haematoma[38,39] putting meticulous primary layered closure ahead of more aggressive primary intervention. Importantly none of the readmissions for CSF leak in our series were in the endoscopic surgery group, so prophylactic lumbar drainage would not have reduced readmissions but is worth considering in the open group with a high BMI at the time of initial surgery.

Four patients were readmitted with infection including meningitis, wound infection, and sinusitis, representing 28.6% of those readmitted. This is higher than a recent large series of 43,356 patients where 30-day readmission rates for postoperative infection after cranial procedures have been shown to be between 2.9 and 6.1%.[20] Conversely, in the largest study of readmissions following a neurosurgical procedure, the infection rate was 29.5%.[21] The higher proportion in our series is likely secondary to the nature of SBS having an increased propensity for complication. Interestingly, of note is that, all patients readmitted with infection had a BMI greater than 30 kg/m^2 and two of the four patients were smokers. Increased surgical site infections have been linked to body habitus and a recent series of 11,510 who underwent a craniotomy for tumor demonstrated that amongst WHO class I to III obese patients, the risk of surgical site infection was significantly higher.[40]

Surgical site infection (SSI) is well known as a complication of smoking a recent series of 67,405 patients who underwent spinal surgery showed that smokers were at increased risk of SSI.[41] From our data, it is difficult to form a direct link between risk of 30-day readmission for SSI and smoking; however, smoking is an independent risk factor for SSI and overall numbers of smokers were higher in the readmissions group (35.7%) in our series compared with those not readmitted (20.8%).

The data here are suggesting that being obese or a smoker or both are more likely to cause complications post SBS and that those readmitted within 30 days following discharge are more likely to be smokers or have a BMI greater than 30 kg/m^2. There are conflicting reports in the literature, one series reporting no significant effect on 30-day readmission and outcomes in those patients who are obese.[36] Others reporting that high BMI is an independent predictor of 30-day hospital readmission after elective spine surgery.[35] Certainly, in our series, 10 of the 14 readmitted were classed as obese suggesting a causal link between obesity and 30-day readmission in our series.

All patients are warned preoperatively about the risks of smoking and obesity on postoperative complications including CSF leak, poor wound healing, and deep vein thrombosis. It may be prudent to enrol patients onto weight management or smoking cessation programs prior to undergoing a procedure. It may not be appropriate to delay operating if there is a risk associated with this, for example, deteriorating vision requiring urgent intervention. Furthermore, while patients can be counselled against individual risks, patient preference and choice mean that uptake of preoperative measures will be down to the individual. Nevertheless, highlighting the risks of obesity and smoking for patients undergoing skull base procedures with careful preoperative counselling may reduce adverse outcomes. Perioperative infection could be minimized further. There are some reports that show that use of a combination of broad-spectrum antibiotics in patients undergoing SBS has been shown to reduce perioperative morbidity.[42] All our patients have intraoperative antibiotics given at four hourly intervals during the procedure. However, given some evidence,[42] it may be prudent to apply a broader regimen of antibiotic cover to prevent postoperative infection and subsequent readmission.

Limitations

There are limitations to this study. This is a single institution, single surgeon, retrospective analysis with a relatively small number of patients. How the data reflect across several different surgeons and across institutions would provide a more detailed overview. Nevertheless, rates of readmission and complications including those for CSF leak and infection are comparable to those published in the literature. While we were able to follow-up all patients and enquire about most admissions to different units, for some patients ($n = 5$), this was not possible. Additionally, smoking and BMI data were not available for all patients but in those studies, there appears to be a clear link with delayed morbidity.

Conclusion

The rate of 30-day readmissions in this series is in line with published data. Skull base surgery is a high-risk subspecialty and CSF and infection related complications remain frequent. In this series, smoking and raised BMI may be indicators for within 30-day readmission and complications in this population, raising the question of risk factor modification prior to elective intervention.

Disclosure
Some results contained in this paper were presented at EndoBarcelona 2018.

Conflict of interest
None.

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