Reports of Investigation

Early postoperative complications following neurosurgical procedures

Pirjo H. Manninen MD FRCPC,
Sitaram K. Raman MBBS FFARCS,
Kevin Boyle MBCHB FRCA,
Hossam El-Beheiry MBBCH FRCPC

Purpose: To assess the incidence and characteristics of early postoperative complications in patients following neurosurgical procedures.

Methods: All patients undergoing neurosurgery during a four month period were followed postoperatively for up to four hours in the post anesthetic care unit or intensive care unit. Patient information and all complications were documented by the investigators on a standardized form. Complications were classified as respiratory, cardiovascular, nausea and vomiting, shivering and other. Risk factors analyzed for the occurrence of complications included age, sex, ASA status, type of surgery, elective or emergency surgery and postoperative placement.

Results: Four hundred eighty six adult patients were followed, but in 55 patients the trachea remained intubated during the four hour study period and they were eliminated from the analysis of postoperative complications. At least one complication occurred in 54.5% of the remaining 431 patients. Respiratory problems occurred in 2.8%, trauma to the airway in 4.4%, cardiovascular complications in 6.7%, neurological in 5.7% and nausea and/or vomiting in 38%. The highest incidence of patients with complications was during spine (65%) and vascular (66%) surgery, compared with tumour (47%) and other (43%) surgery, $P < 0.05$. Other risk factors included age < 70 yr for nausea and vomiting ($P < 0.02$), and elective surgery for spine and vascular surgery ($P < 0.001$).

Conclusion: There was a high incidence of early postoperative complications in neurosurgical patients. The most common problem was nausea and vomiting especially in the younger patient undergoing elective spine surgery.

Objectif : Évaluer les caractéristiques et l'incidence de complications postopératoires précoces chez des patients qui ont subi une intervention neurochirurgicale.

Méthode : Pendant quatre mois, tous les patients qui avaient subi une neurochirurgie ont été suivis, pendant une période pouvant aller jusqu'à quatre heures, à la salle de réveil ou à l'unité des soins intensifs. Les chercheurs ont noté sur un formulaire standardisé les informations recueillies auprès du patient et toutes les complications. Ces dernières ont été classées en complications respiratoires, cardiovasculaires, nausées et vomissements, frissons et autres. Les facteurs de risques analysés selon la survenue des complications comprenaient l'âge, le sexe, l'état ASA, le type de chirurgie, l'aspect prévisible ou non de la chirurgie et le placement postopératoire.

Résultats : Quatre cent quatre-vingt six patients adultes ont été suivis, mais on a exclu 55 patients de l'analyse des complications postopératoires puisqu'ils ont eu besoin d'intubation pendant les quatre heures de l'expérience. Une complication au moins est survenue chez 54,5 % des 431 autres patients. Des complications respiratoires sont survenues chez 2,8 % des patients, cardiovasculaires chez 6,7 %, neurologiques chez 5,7 %; un traumatisme des voies aériennes chez 4,4 % et des nausées et/ou des vomissements chez 38 %. La plus forte incidence de complications a été enregistrée pendant la chirurgie rachidienne (65 %) et vasculaire (66 %), comparativement à la chirurgie pour une tumeur (47 %) ou à d'autres chirurgies (43 %), $P < 0,05$. Les autres facteurs de risque comprenaient l'âge < 70 ans pour les nausées et les vomissements ($P < 0,02$) et le caractère non urgent de la chirurgie rachidienne et vasculaire ($P < 0,001$).

Conclusion : Il y a eu une forte incidence de complications postopératoires précoces chez les patients admis en neurochirurgie. Les nausées et les vomissements se sont présentés le plus souvent et surtout chez les jeunes patients subissant une chirurgie rachidienne.

From the Department of Anesthesia, University of Toronto, The Toronto Hospital, Western Division, 399 Bathurst Street, Toronto, Ontario, Canada, M5T 2S8.

Address correspondence to: Dr. Pirjo H. Manninen, Phone: 416-603-5118; Fax: 416-603-6494; E-mail: pmanninen@torhosp.toronto.on.ca

Accepted for publication September 18, 1998

PATIENTS are at increased risk of morbidity in the immediate postoperative period. Numerous studies and surveys have reported the incidence of immediate postoperative complications occurring for the general surgical population from 3% up to 30%.[1-5] The most common complications are respiratory, cardiovascular, and nausea and vomiting. The extent and gravity of these complications arising in the neurosurgical population has not been well defined. The purpose of this study was to assess prospectively the incidence and characteristics of complications occurring in the immediate postoperative period in adult patients undergoing neurosurgical procedures.

Methods

Approval was obtained from the institutional ethics committee. All consecutive patients undergoing a neurosurgical procedure over four months from June to September 1996 were included. Procedures for functional surgery such as chronic pain and movement disorders were not included. The postoperative study time was limited up to the first four hours in either the post anesthetic care unit (PACU) or intensive care unit (ICU). There was no attempt made to change or influence the standard practice of patient care.

A designated, standardized form was used to collect all the information and this was by a research assistant and/or by the investigators. Information included demographic data, diagnosis, surgical operation, whether the procedure was elective or an emergency, and the preoperative assessment of the patient including the neurological status. When the patient arrived in the PACU or ICU, the nurse measured and recorded all vital signs (blood pressure, heart rate, respiratory rate, SpO_2) and neurological assessment (level of consciousness, motor and sensory function). All new neurological deficits were noted. This information and all untoward events and complications that occurred during the first four hours in the PACU or ICU were documented on the designated form. The intraoperative course also was reviewed and untoward events recorded on the anesthetic chart were documented. Postoperative complications that were assessed in this review are defined in Table I. The specific assessment of postoperative pain was not part of this study. If the patient arrived with the trachea intubated, the time of extubation was recorded. Patients whose lungs were electively ventilated postoperatively and when the trachea remained intubated for the duration of the four hours were excluded from the analysis of the data for complications. Statistical analysis for the mean ages was with one way ANOVA and unpaired t-test for multiple comparisons between every two groups. Gender proportion of patients with complications and proportion of number of complications in every group were compared by the Tukey-type multiple comparison testing.[6,7] To identify risk factors for the occurrence of complications, Chi-square analysis was used to test the association between the occurrence of complications and each of the following factors: age, sex, ASA status, elective or emergency surgery, type of surgery, and postoperative placement. The statistical analysis was performed using SPSS version 6.1.2 (SPSS Inc. Chicago, Illinois): $P < 0.05$ was considered significant.

Results

Four hundred and eighty six patients were included in this study. The data sheets for another 24 patients were incomplete and not included. Routine practice for the technique of anesthesia and the postoperative placement was followed. The decision to provide general anesthesia or conscious sedation with local anesthesia was largely determined by the surgeon according to the type of procedure being performed. All awake craniotomies for tumour were at the request of the surgeon for these specific patients. Routine practice was followed for the remaining procedures; local anesthesia and conscious sedation for stereotactic biopsy, ventriculostomy, burr holes for hematoma,

TABLE I Definition of complications

1. Respiratory		
	A. Depression	Decrease respiratory rate (<8 bpm) Decrease SpO_2 (<90%) Dyspnea, bronchospasm
	B. Reintubation	
	C. Airway	Trauma to lips, tongue, teeth, sore throat, hoarseness
	D. Pulmonary edema	
2. Cardiovascular		
	A. Arrhythmias	Heart rate* Arrhythmias
	B. Hemodynamic	Blood Pressure*
	C. Myocardial ischemia	Chest pain, ECG change
3. Neurological		Unexplained delayed awakening New motor or sensory deficit New cranial nerve palsy Seizures
4. Nausea/Vomiting		
5. Shivering		
6. Other:		Excessive bleeding

* a persistent change in heart rate or blood pressure (± 20% from preoperative values) that required the attention of a physician and/or appropriate treatment

TABLE II Demographic data

Group		*n*	*Sex (M/F)*	*Age (yr)*	*Emergency Procedures*	*Ventilated**
BrainTumour	Craniotomy	82	38/44	49 ± 16	10	8
(n = 132)	Awake Craniotomy	21	12/9	53 ± 19	1	0
	Stereotactic biopsy	29	11/18	59 ± 16	3	0
Spine	Cervical	62	41/21	51 ± 15	8	12
(n = 169)	Thoracic/lumbar	107	57/50	50 ± 17	6	2
Vascular	Carotid endarterectomy	26	14/12	66 ± 9	0	0
(n = 54)	Aneurysm	15	9/6	51 ± 13	7	2
	AVM	13	9/4	45 ± 15	1	5
Other†		131	68/63	54 ± 18	63	26
(n = 131)						
Totals		486	259/227	52 ± 17	99	55

values are mean ± SD

n = number of patients

* = patients who were postoperatively ventilated for more than four hours

† = Other included CSF drainage (38), peripheral nerve (28), burr hole (18), ventriculostomy (17), omaya reservoir (12), and others (18)

AVM = arteriovenous malformation

TABLE III The number of patients with complications

Group *n*	*Tumour* *124*	*Spine* *155*	*Vascular* *47*	*Other* *105*	*Total* *431*
1 Complication n (%)	45(36%)	68 (44%)	24(51%)	42(40%)	179(41.5%)
2 Complications n (%)	11 (8.9%)	29 (18.7%)	6(12.8%)	3 (2.9%)	49(11.4%)
3 Complications n (%)	2 (1.6%)	4 (2.5%)	1 (2.1%)	0	7 (1.6%)
Total number ≥ 1 complication	58 (47%)	101(65%)*	31(66%)*	45 (43%)	235 (54.5%)
Total number of complications	73 (59%)	138 (89%)*	39 (83%)*	48 (48%)	298 (69%)

* $P < 0.05$ from Tumour and Other

n = number of patients

% = percentage of total number of patients

peripheral nerve decompression, and insertion of Omaya reservoirs. All remaining procedures were performed under general anesthesia. The postoperative placement of patients was according to standard hospital protocol. After craniotomy under general anesthesia and all vascular procedures, the patients were taken directly to the ICU. After awake craniotomy, patients recovered in the PACU for four hours, then were transferred to the ward. Stereotactic biopsy patients were recovered in the PACU. After spine procedures placement was according to the extent of the procedure and preoperative condition of the patient. All other procedures were determined by the perioperative condition of the patient. All patients were transported from the operating room with supplemental oxygen by mask to the PACU or ICU and continued to breathe supplemental oxygen with continuous monitoring of SpO_2 until discharge or until they were stable breathing room air.

For analysis of the results, the patients were divided into four major surgical groups; brain tumour (132), spinal surgery (including spinal tumours) (169), vascular surgery (54), and other (131) (Table II). The fourth group included a wide variety of different procedures including CSF drainage (38), peripheral nerve (28), burr hole for hematoma (18), ventriculostomy (17), Omaya reservoir (12), and others (18). Postoperatively, 49% of the patients recovered in the PACU. Three patients for an awake craniotomy were electively placed in the ICU. Thirty two percent of the spine and 44% of the other group were transferred directly to the ICU postoperatively. There were only eight outpatients in this patient population and these were all patients with peripheral

TABLE IV Summary of number of patients with specific complications

	Respiratory		Cardiovascular		Neurological	Nausea/vomit	Shivering	Bleed
	SO_2	Airway	Rate	Press				
Tumour								
General (74)	2	2	1	3	9	28	13	1
Awake (21)	0	0	1	1	3	4	0	10
Biopsy (29)	0	0	0	0	1	3	1	0
Total (124)	4 (3.2%)		6 (4.8%)		13 (10%)	35 (28%)*	14 (11%)	1 (0.8%)
Spine								
Cervical (50)	1	10	1	3	1	32	9	10
Thora/Lumb (105)	3	6	4	3	3	46	15	1
Total (155)	20 (13%)		11 (7%)		4 (2.6%)	78 (50%)* α	24 (15.5%)	1 (0.6%)
Vascular								
CEAE (26)	2	0	3	5	2	12	1	0
Aneurysm (13)	1	0	0	1	2	4	1	0
AVM (8)	1	0	0	0	0	2	1	1
Total (47)	4 (8.5%)		9 (19%)		4 (8.5%)	18 (38%)*	3 (6.4%)	1 (2.1%)
Other								
(105)	0	3	0	3	4	36	2	0
Total (105)	3 (2.8%)		3 (2.8%)		4 (3.8%)	36 (34.3%)*	2 (1.9%)	0
Overall Total (%)	12 (2.8%)	19 (4.4%)	10 (2.3%)	19 (4.4%)	25 (5.7%)	167 (38.7%)*	43 (9.9%)	3 (0.7%)

Rate = change in heart rate or arrhythmia

Press = change in blood pressure

* = most common complication within each group ($P < 0.05$)

α = greater compared to Tumour, Vascular, and Other ($P < 0.050$)

nerve surgery under local anesthesia. The ASA classification of all patients was 16% ASA 1, 44% ASA 2, 30% ASA 3, and 10% ASA 4&5.

Overall, 99 procedures (20%) were classified as emergency (Table II). In 55 patients of the total (486) the tracheas were intubated and lungs ventilated for the study duration and thus excluded from analysis of the complications. Of these, 36 (65%) were emergency procedures. The reasons for the patient requiring intubation and ventilation were the poor preoperative condition of 34 patients (brain tumour 4, spine 3, vascular 3, other 24). In 21 patients, the trachea was electively left with the trachea intubated because the surgery was prolonged, difficult or unstable (brain tumour 4, spine 11, vascular 4, other 2).

The analysis of the complications as defined in Table I which occurred in the 431 patients studied, showed that 54.5% of the patients experienced at least one complication (Table III). Most patients (41.5%) had only one complication, but 49 (11.4%) had two and seven (1.6%) had three complications. The overall incidences of complication in spine and vascular groups were greater than in the tumour and in the other groups ($P < 0.05$). There were no complications in the eight outpatients. Table IV shows the complications according to type and the total number within each group.

Respiratory complications resulting in respiratory depression or reintubation occurred in 12 patients (2.8%). In two patients (0.46%) reintubation was required. A decrease in respiratory rate occurred in two patients (lumbar spine 1, aneurysm 1) and was treated with naloxone. A decrease in SpO_2 occurred in four patients; from postoperative aspiration following lumbar spine surgery (1), increased secretions (1), and decrease level of conscious (2). These patients were treated with increased oxygen administration, suctioning and, in one patient, reintubation was required after loss of consciousness from a subdural hematoma one hour after a craniotomy for AVM. Dyspnea associated with wheezing occurred in four patients (brain tumour 1, lumbar spine 1, carotid endarterectomy 2): all

required treatment with salbutamol inhalation. One patient developed stridor after he extubated himself following a ventricular peritoneal shunt insertion. He required racemic epinepherine and oxygen. Another patient developed upper respiratory obstruction 15 min after extubation following excision of spinal cervical cord tumour and reintubation was required.

Trauma to the airway occurred in 19 patients (4.4%). Seven patients after spine surgery and two after craniotomy for tumour had injuries to their tongue or lips. Ten patients complained of hoarseness and/or sore throat, one after ventricular peritoneal shunt insertion and the others following spine surgery.

Cardiovascular complications occurred in 29 patients (6.7%). These consisted of an increase in heart rate (4), decreased heart rate (5), arryhthmia (PVC) (1), increase in blood pressure (10) and a decrease in blood pressure (9). There were no events of myocardial ishemia as evident on routine ECG monitoring or complaints of chest pain by the patient. There were no episodes of pulmonary edema.

Neurological complications occurred in 25 patients (5.7%). They consisted of a new sensory or motor deficit (8), cranial nerve deficit (6), confusion/delirium (5), dysphasia (3), and delayed awakening (3). An acute intracranial hemorrhage requiring emergency reopening of the craniotomy occurred on two occasions (brain tumour 1, AVM 1).

Nausea and vomiting were the most frequently occurring complications in all groups ($P < 0.05$) (Table IV). In total, 167 patients (38.7%) complained of nausea and/or vomited. The incidence of this was greatest in the spine group (50%) compared with tumour (28%), vascular (38%), and other (34%) ($P < 0.05$).

Shivering was documented in 10% of patients. We did not grade the degree of shivering or correlate it with the patient's intraoperative or postoperative temperature as the techniques and recordings of temperature varied and were inconsistent. The other complication was excessive bleeding which occurred in three patients. Following craniotomy, for a large pineal tumour, one patient had delayed awakening. A CT scan at three hours after surgery showed an intraventricular hemorrhage and the patient was returned to the operating room for a ventriculostomy. The second patient developed loss of consciousness following resection of an AVM. Reintubation and reopening were required to evacuate a large subdural hematoma. The third patient, following lumbar laminectomy and fusion, continued to bleed postoperatively from his wound and required multiple units of blood transfusion in the ICU.

Intraoperative complications or events that were documented on the anesthetic record occurred in 58 patients (13.5%). In 19, (4.4%) this intraoperative complication led to a patients similar postoperative complication (respiratory 5, cardiovascular 11, bleeding 3) Two patients, during carotid endarterectomy, had intraoperative episodes of bronchospasm and also developed bronchospasm in the ICU. One patient, following stereotactic biopsy, developed change in respiratory rate intraoperatively and this continued postoperatively. In one patient tracheal reintubation was required in whom intubation had been a difficult and stridor developed after extubation. Changes in heart rate occurred in eight patients and in blood pressure in three. Three patients who developed hypotension from blood loss requiring fluids and/or blood postoperatively had had similar events intraoperatively.

Possible risk factors for patients who developed postoperative complications were assessed. The sex of the patients was not a risk factor. The ASA classification of the patients compared to the number of patients with complications was not different (ASA 1 (67%), ASA 2 (55%), ASA 3 (51%), ASA 4&5 (47%). More patients with complications (74%) underwent elective surgery (n=368) than emergency surgery (n=63, 41%) ($P < 0.0001$). The type of surgery for the elective group that showed the greatest incidences of complications were the spine (90%) and vascular (88%) compared with tumour (59%), and other (54%), ($P < 0.001$). There was no difference in the incidence of complications amongst the different groups for emergency surgery. The postoperative placement of patients was a risk factor for only the spine group: 80% of patients transferred to ICU had a complication compared with 58% in PACU ($P < 0.03$). There was no difference amongst the types of complications.

Patients were divided into two groups with respect to age < 70 yr, (n=360) and ≥70 yr (n=71). The younger age group had more patients with complications (58% *vs* 42%) ($P < 0.02$). The incidence of nausea and vomiting was greater in the younger (71%) than in the older (31%) age group ($P < 0.008$). The other complications were not different between the two age groups.

Discussion

In this review of the early postoperative complications in patients undergoing neurosurgical procedures, we found the overall incidence to be higher than previously reported for the general surgical population. In 1986, Cohen *et al.* in a survey of 112,721 anesthetics during two different periods reported complications in 3.1% and 5.9%.[1] The increase during the second period was due to changes in anesthesia practice with increased use of balanced anesthesia and monitoring.

Also, more seriously ill patients were treated in the later period. In 1987, Zelcer *et al.* followed 443 patients and found that 30% had at least one complication.[2] Cooper *et al.* in 1987 in their study of anesthesia related events and the influence of the pulse oximeter in the recovery room found the rate of complications to be 7.1% for 12,088 patients.[3] Hines *et al.*, in 1992, reported a complication rate of 23.7% in 18,473 consecutive patients.[4] In our review, 54.5% of 431 neurosurgical patients had at least one postoperative complication in the PACU or ICU. The higher overall incidence in the neurosurgical population of our study may be due to our small sample size, the method of data collection, the high incidence of nausea and vomiting, or that this group of patients is more susceptible to complications in the immediate postoperative period. Our most common complication was nausea and vomiting which occurred more frequently than in the previous studies. However, the incidence of respiratory and cardiovascular complications were not different. The period of our study was the first four hours after arrival in the PACU or ICU. This time was chosen to reflect our practice. Patients with major procedures who do not go to ICU, such as after awake craniotomy and cervical spine surgery, are routinely observed in the PACU for four hours and then transferred to the ward.

Respiratory complications are of great concern in any patient, but are especially worrisome in a neurosurgical patient. Previous reports found an incidence ranging from 1.3 to 6.9%.[1–4,8–10] In 1991 Parr *et al.* found the incidence of early respiratory complications in 16,065 patients to be 2.95%.[9] They found the incidence of complications was related to the level of consciousness at time of arrival, independent of ASA or age. The most common problems were related to hypoventilation, airway obstruction and residual paralysis. Rose *et al.*, in 1994, found the occurrence of a critical respiratory event in PACU to be 1.3% of 24,157 patients who had a general anesthetic.[10] The most common critical events were hypoxemia (SpO_2) followed by hypoventilation and airway obstruction. In our review, we found an overall incidence of respiratory depression (decrease in SpO_2 and respiratory rate) of 2.8% which is similar to these previous studies. The rate of reintubation has been described from 0.02% to 0.1% and in our study was 0.46%. [4,10] One might have expected a higher incidence of respiratory complications in the neurosurgical population due to the nature of their disease, prolonged surgery, and possible neurological injury preoperatively and intraoperatively that might compound with other causes of desaturation. However, respiratory complications are events that the anesthetist attempts vigorously to avoid in neurosurgical patients. This is done by ensuring that the patient emerges from anesthesia completely and promptly, and by the close observation and monitoring of the patient, frequently in the ICU. This was our routine practice and, as well, all our patients were transported with and remained breathing supplemental oxygen until fully recovered.

We classified traumatic airway problems, such as trauma to the lips, tongue, teeth and complaints of a sore throat or hoarseness separately from other respiratory complications due to the nature of the surgical procedures of neurosurgical patients. These injuries may occur during intubation but also can easily happen when patients are placed into various positions, such as prone, and when there is no or limited visibility of the face for a long duration. These complications occurred in 19 patients (4.4%), 16 of whom were placed in the prone position for spine surgery.

Cardiovascular complications have been reported to occur in from 2.3% to 15.3% of patinets.[1,2,4,11] In 1996, Rose *et al.* examined the cardiovascular events in the PACU to determine their relationship to outcome.[11] One or more cardiovascular events occurred in 7.2% of all admissions to PACU of 18,380 patients. The events included hypertension (2%), hypotension (2.2%), tachycardia (0.9%), and bradycardia (2.5%). The overall incidence in our study was 6.7% which is similar to these previous studies. There were no major cardiovascular events such as pulmonary edema or myocardial ischemia during the study period.

Nausea and vomiting was the most frequently occurring complication, with an overall incidence of 38.7% in our study. The previously quoted studies [1,2,4] reported incidences ranging from 5.1% to 9.8%. Other large series have reported the rate of nausea and/or vomiting to be 20-30%, and more specific smaller studies have found even higher incidences up to 67%.[12] In 1997, Fabling *et al.* reported an incidence of nausea and/or vomiting during the first 48 hr postoperatively in 54% of patients in a retrospective study of 199 patients undergoing elective craniotomy.[13] The incidence in our patients undergoing a craniotomy for brain tumour with general anesthesia was 38%. In our review, patients were not routinely given intraoperative antiemetics. Patients did receive antiemetics postoperatively as needed and frequently at the discretion of the nurse it was given prophylacticly with the administration of an opioid for pain. The interesting finding in our review was that the highest incidence of nausea and vomiting occurred in patients undergoing elective spinal surgery and in the younger age group. One possible explanation is the increased use of opioids, especially morphine,

both intra and postoperatively, for these procedures than in the other neurosurgical operations. This area needs further investigation.

Shivering is a complication that may increase postoperative morbidity. Efforts are usually employed in neurosurgical patients to avoid shivering to prevent any harmful sequele such as an increase blood pressure. Another confounding factor in recent neuroanesthesia practice is the use of moderate hypothermia during vascular procedures such as aneurysm clipping. In this study we did not grade the degree of shivering, nor did we try to correlate the presence of shivering to the patient's intra or postoperative temperature. There was too much variability in how and when the patient's temperature was measured both intraoperatively and postoperatively, and with the intraoperative management of the patient's temperature.

Intraoperative problems may predispose the patient to postoperative complications. In previous studies, Cohen *et al.* reported an incidence of 7.6% and 10.6% of intraoperative complications, Hines *et al.* had 5.1%, and Cooper *et al.* reported 13.8%.[1,3,4] The most common intraoperative complications leading to postoperative complications were hypertension and hypotension. Rose *et al.* also noted a strong relationship between cardiovascular events in PACU and similar cardiovascular problems in the operating room suggesting that the management of the original problem of the patient may have been inadequate or unsuccessful.[11] Overall, in our study, 4.4% of patients had an intraoperative complication that was similar to the problem in the postoperative period. However, our information is limited in that data regarding intraoperative events was only from what the anesthetist had written on the anesthetic record.

Neurological complications occurred in 5.7% of patients, but this would not be unexpected in this group of patients. Previous studies did not include many patients under going neurosurgical procedures as most of these patients would have been admitted to ICU and thus were excluded from their studies.

Previous studies have examined various risk factors for the development of postoperative complications. These include age, sex, site of surgery, duration of surgery, the ASA status of the patient, technique of anesthesia, and whether the procedure was emergency or elective. In our study, age < 70 yr was a factor for occurrence of nausea and vomiting, but not for other complications. This is in contrast to studies by Rose *et al.* where age > 60 yr was a risk factor for respiratory and cardiovascular events.[10,11] We found that the type of surgical procedure was a predictor of complications in that the spine and vascular groups had the highest incidences. Also, patients undergoing an elective operation had a greater incidence of complications in the spine and vascular groups. There was no difference amongst the type of complications in contrast to studies by Hines and Rose, where the emergency procedures had greater incidence of respiratory and cardiovascular complications.[4,10,11] These differences may be due to the small numbers of our study and the different patient population. The ASA status was not a positive risk factors in our study.

Limitations of our study include the reliability of the data collected and the small sample size. Most of the information collected was from the notes recorded by the nurses over the four hour study period. They were not specifically informed about the study, thus not all short lived events may have been observed and/or documented by the nurse. All information was collected by two of the authors assisted by a research technician, so the recording of the information was standardized. Intraoperative events and ASA classification were influenced by the subjective recording of the anesthetist giving the anesthetic. However, our findings are not dissimilar to previous studies for respiratory and cardiovascular complications. Further study is required in area of the nausea and vomiting and the influences of temperature in the neurosurgical patients.

In conclusion, postoperative complications are common in neurosurgical patients. The incidence of respiratory and cardiovascular events in the PACU or ICU is not dissimilar from the general population. Nausea and vomiting are the major problems in this group, particularly the younger age patient undergoing elective spine surgery.

Acknowledgment

The authors wish to acknowledge Dr. Shanthini Sundareswaran for her assistance in collection of the data for this study.

References

1 *Cohen MM, Duncan PG, Pope WDB, Wolkenstein C.* A survey of 112,000 anaesthetics at one teaching hospital (1975- 83). Can Anaesth Soc J 1986; 33: 22–31.

2 *Zelcer J, Wells DG.* Anaesthetic-related recovery room complications. Anaesth Intensive Care 1987; 15: 168–74.

3 *Cooper JB, Cullen DJ, Nemeskal R, et al.* Effects of information feedback and pulse oximetry on the incidence of anesthesia complications. Anesthesiology 1987; 67: 686–94.

4 *Hines R, Barash PG, Watrous G, O'Connor T.* Complications occurring in the postanesthesia care unit: a survey. Anesth Analg 1992; 74: 503–9.

5 *Rose DK.* Recovery room problems or problems in the PACU. Can J Anaesth 1996; 43: R116–22.
6 *Zar JH.* The binominal distribution and contingency tables. *In:* Zar JH (Ed.). Biostatistical Analysis, 2nd ed. Englewood Cliffs: Prentice-Hall, 1984: 61–78, 400–5.
7 *Levy KJ.* Some multiple range tests for variances. Educational and Pschological Measurement 1975; 35: 599–604.
8 *Beard K, Jick H, Walker AM.* Adverse respiratory events occurring in the recovery room after general anesthesia. Anesthesiology 1986; 64: 269–72.
9 *Parr SM, Robinson BJ, Glover PW, Galletly DC.* Level of consciousness on arrival in the recovery room and the development of early respiratory morbidity. Anaesth Intensive Care 1991; 19: 369–72.
10 *Rose DK, Cohen MM, Wigglesworth DF, DeBoer DP.* Critical respiratory events in the post anesthesia care unit. Patient, surgical, and anesthetic factors. Anesthesiology 1994; 81: 410–8.
11 *Rose DK, Cohen MM, DeBoer DP.* Cardiovascular events in the postanesthesia care unit. Contribution of risk factors. Anesthesiology 1996; 84: 772–81.
12 *Watcha MF, White PF.* Postoperative nausea and vomiting. Its etiology, treatment, and prevention. Anesthesiology 1992; 77: 162–84.
13 *Fabling JM, Gan TJ, Guy J, Borel CO, El-Moalem HE, Warner DS.* Postoperative nausea and vomiting. A retrospective analysis in patients undergoing elective craniotomy. J Neurosurg Anesthesiol 1997; 9: 308–12.