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Outcome Following Posterior Fossa Craniectomy in Patients in the Sitting or Horizontal Positions

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Controversy continues to surround the use of the sitting position for neurosurgical procedures. This retrospective review of 579 posterior fossa craniectomies performed over a 4-yr period from 1981 through 1984 examines outcome following these procedures performed with the patients in either the sitting (n = 333) or horizontal (supine, prone, lateral, park bench) (n = 246) position. Multiple preoperative, intraoperative, and postoperative variables were analyzed. Venous air embolism occurred significantly more often in patients in the sitting position (45% *versus* 12%). However, no morbidity or mortality was attributed to venous air embolism. The incidence of hypotension with positioning was not different by position (19% in the sitting patients and 24% in the horizontal patients). Average blood replacement was significantly lower in the sitting patients (359 ml *versus* 507 ml), and the incidence of transfusion of greater than two units of blood was significantly higher in the horizontal patients (13% *versus* 3%). Postoperative cranial nerve function was significantly better in patients in the sitting group as compared to those in the horizontal group. The incidence of perioperative cardiopulmonary complications was not different between groups. These outcome data suggest that there are potential advantages and disadvantages of both the sitting and horizontal positions without supporting a significantly increased morbidity or mortality associated with either position. (Key words: Complications: venous air embolism. Neurosurgery, posterior fossa craniectomy: outcome. Position, sitting, supine: outcome.)

THERE IS CONSIDERABLE controversy among neurosurgeons and neuroanesthesiologists regarding the usefulness of patients being in the sitting surgical position as compared to the horizontal positions (which include the supine, prone, lateral, and park bench positions) for access to the posterior fossa. The sitting position provides several possible advantages to both surgeon and anesthesiologist. Specific advantages include improved surgical exposure and anatomical orientation, decreased bleeding, improved cerebrospinal fluid (CSF) and blood drainage, less impairment of diaphragmatic movement and improved ventilation with lower airway pressures, improved access to the endotracheal tube, thorax, and extremities, and ability to observe the face for signs of surgical stimulation of cranial nerves.[1–3] There are also significant potential disadvantages to the sitting position that include increased incidence of venous air embolism (VAE), undesirable hemodynamic changes, tension pneumocephalus, postoperative bleeding, lingual or laryngeal edema, brachial plexus, sciatic, or peroneal nerve injuries and quadriparesis.[1–3]

Over a 4-y period from 1981 through 1984, the practice at this institution has undergone a change. In 1981, the majority of posterior fossa craniectomies were done with the patients in the sitting position, but, by 1984, the practice had changed so that more posterior fossa craniectomies were performed with patients horizontal (fig. 1). The same group of surgeons and anesthesiologists performed these procedures, and surgical technique was basically unchanged. In addition, there were no major changes in anesthetic techniques and intraoperative monitoring. The only major change in our practice over this 4-y period was a change in the more commonly utilized position from sitting to horizontal. This provided a unique opportunity to examine differences in outcome that might be attributable to surgical position in a large group of patients over a short time period when other factors contributing to outcome were essentially unchanged.

Materials and Methods

This is a retrospective review of 579 records of patients who underwent posterior fossa craniectomy at the Mayo Clinic from 1981 through 1984 in either sitting or horizontal positions. In the sitting position, patients were in a 60–90° head-up tilt. The horizontal positions utilized at our institution include supine, prone, lateral, and park bench, and patients were 0–20° head up. Surgical position was determined by the neurosurgeon for each patient, and patients were not randomly assigned to the sitting or horizontal positions. A survey of the neurosurgeons performing posterior fossa procedures at this institution revealed that type and location of lesion are the primary factors in the choice of surgical position. In their opinion, other medical problems are rarely considered in their decision concerning surgical position.

Data were collected on each patient by a detailed chart review of all preoperative medical evaluations, hospital records, and post-hospitalization follow up. In particular, preoperative data collected included age, sex, weight, height, neurologic status, and history of cardiac or respiratory disease. Preoperative neurologic status was determined from a review of the preopera-

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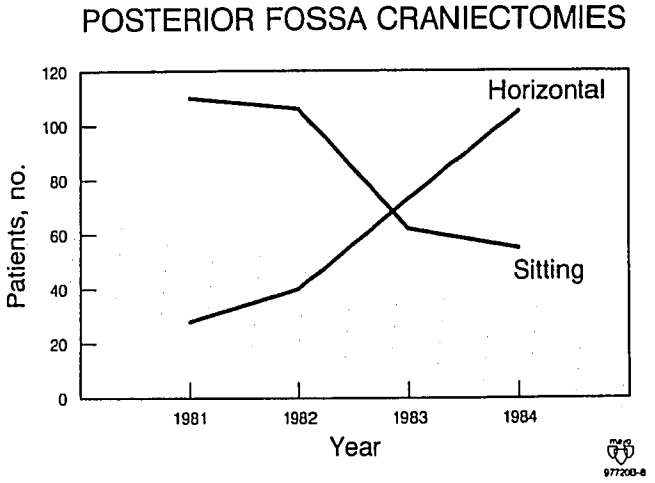

FIG. 1. Number of posterior fossa craniectomies by patient position by year.

tive exam by a neurologist, as well as diagnostic tests. History of prior stroke or transient ischemic attack, evidence of specific cranial nerve involvement, somatic sensory or motor deficit, ataxia, dysphagia, nausea, altered mentation, estimated tumor size when noted from computerized tomography, and previous neurosurgical procedures were recorded. Cardiac status was evaluated by review for prior myocardial infarctions, timing of prior myocardial infarctions, angina and its severity, prior or current episodes of congestive heart failure, history of arrhythmias, hypertension, cardiac medications, prior cardiovascular surgery, and an abnormal electrocardiogram (ECG). Those patients with a history of hypertension, angina regardless of class, current or prior episodes of congestive heart failure, prior myocardial infarction, prior cardiovascular surgery, requiring any cardiac medication, or with ECG evidence of arrhythmia or prior MI were all considered to have cardiovascular disease. Patients with symptoms of respiratory disease, such as chronic cough or dyspnea, abnormal chest x-ray, or abnormal pulmonary function tests, were considered to have respiratory disease. The American Society of Anesthesiology physical status assigned preoperatively to each patient by the attending staff anesthesiologist was also recorded.

Intraoperative data collected included anesthetic technique, monitoring, hemodynamic changes, occurrence of VAE, blood replacement, technical surgical difficulties, and surgical pathology. In evaluating anesthetic technique, the induction agent, muscle relaxants utilized for tracheal intubation and maintenance, primary anesthetic agent for maintenance, and the use of nitrous oxide were recorded. To evaluate the occurrence of hemodynamic changes, episodes of hypotension defined as decrease of 20% or more in the systolic blood pressure below the preoperative ward pressure, as well as their timing (with positioning or during the surgical procedure) and development of arrhythmias were recorded. Venous air embolism was diagnosed on the basis of development of characteristic changes in the precordial Doppler sounds. Hemodynamic changes during VAE were defined as a decrease in systolic blood pressure of 20% or more, or the development of arrhythmias.

Postoperative data collected included neurologic status, cardiopulmonary complications, surgical complications, and status at long-term follow-up. Evaluation of neurologic status included change in mentation from preoperative level, specific cranial nerve involvement, somatic motor and sensory deficits, and new postoperative cerebrovascular accident or transient ischemic attack. In evaluation of cranial nerve function postoperatively, patients were classified as having the same cranial nerve deficit as present preoperatively, an improvement in function, or a deterioration. The same classification was utilized to classify postoperative somatic sensory and motor function. Cardiac complications evaluated included perioperative myocardial infarction, congestive heart failure, hypotension, and arrhythmias. Respiratory complications included aspiration, prolonged tracheal intubation, and pulmonary emboli. Surgical complications were defined as wound infection and the need for reexploration. The evaluation at long-term follow-up included timing of last follow-up, facial nerve function, and a general estimation of the neurological status (normal, neurologic deficit present but functioning well, incapacitating neurologic deficit, or dead). A total of 156 separate variables were evaluated for each of the 579 cases.

Chi-square tests were used to analyze the incidence of preoperative cardiovascular disease, respiratory disease, sex, VAE, intraoperative hypotension and arrhythmias, transfusion of greater than two units of blood, tumor histology, and postoperative cranial nerve function. The incidence of perioperative myocardial infarction, respiratory complications, and eye injury were compared using the Fisher's exact test. Wilcoxon 2-sample test was used to compare age, weight, height, duration operating, tumor size, and postoperative mental status; Student's *t* test for mean blood replacement; and log rank test by the Kaplan-Meier method for survival data. The relationship of position and tumor type to postoperative cranial nerve function, mentation, and somatic motor function was accessed using multivariant analysis. The relationship of position and a history of cardiovascular disease to the development of intraoperative hypotension was also assessed using multivariant analysis.

Results

PREOPERATIVE

Mean age was slightly but significantly lower for patients in the sitting group, and history of cardiovascular disease was significantly more common in patients operated on in the horizontal positions (20% *versus* 11%), with six (2%) of the sitting patients and 14 (6%) of the horizontal patients having suffered prior myocardial infarctions. Mean weight was also slightly but significantly lower in the sitting patients. Mean height, sex distribution, and incidence of respiratory disease were not different by position. The majority of patients were American Society of Anesthesiologists (ASA) physical status II in both groups, and the distribution of ASA status was not different between groups (table 1).

TABLE 1. Preoperative Factors

	Sitting (n = 333)	Horizontal (n = 246)
Age, years: Mean	42	49*
Range	1–79	1–85
Male	171	110
Female	162	136
Height, cm	163	165
Weight, kg	66	71*
ASA physical status: 1	19 (6%)	30 (12%)
2	206 (62%)	145 (59%)
3	101 (30%)	63 (26%)
4	6 (1.8%)	8 (3%)
5	1 (0.3%)	0
History cardiac disease	36 (11%)	49 (20%)†
History respiratory disease	81 (24%)	75 (30%)
Prior posterior fossa craniectomy	18 (5%)	12 (5%)

* $P < .05$ by Wilcoxon 2-sample test.
* $P < .01$ by Chi-square.

INTRAOPERATIVE

The sitting position was used in 333 procedures, while the horizontal position was used in the remainder (246). Anesthetic technique was similar in both groups, and usually consisted of induction with thiopental, a nondepolarizing muscle relaxant, mechanical ventilation with moderate hyperventilation, and a volatile anesthetic as primary agent (enflurane prior to mid-1982 and isoflurane after mid-1982). Nitrous oxide was used in 99% of patients, and was discontinued whenever venous air embolism was suspected. All patients were monitored using an electrocardiogram, an esophageal stethoscope, and, after 1982, mass spectrometry. Direct arterial pressure with zero at the level of the base of the skull was monitored in 97% of patients. Precordial Doppler was utilized in all patients in the sitting position, but in only 30% of patients in the horizontal positions. Utilization of Doppler monitoring in patients in the horizontal group was similar between patients with different lesions, ranging from 19% in those patients with meningiomas to 36% in patients with Arnold-Chiari malformations. One neurosurgeon frequently utilized Doppler monitoring in patients undergoing posterior fossa procedures to alert him to changes in cardiac rate and rhythm resulting from surgical stimulation of intracranial structures. Doppler was utilized in 50% of patients in the horizontal group operated on by this surgeon. Other neurosurgeons had a lower incidence of Doppler monitoring in the horizontal position. A right atrial catheter was inserted in 95% of sitting patients and in one-third of patients in the horizontal group. CSF drainage was utilized in 59% of patients in the horizontal group and none of the sitting patients. Care was taken with positioning in all patients, with special attention to avoid excessive flexion or turning of the head and to pad any potential pressure points. Pinion head holders were routinely utilized.

Hypotension (defined as a decrease of 20% or more in systolic blood pressure from the ward pressure) was examined during two time periods (table 2). "With positioning" was defined as that time period following induction of anesthesia, but preceeding surgical incision. The second time period was from incision through emergence from anesthesia. The incidence of hypotension was not different by position during either time period. Hypotension with positioning occurred in 19% of the sitting patients and 24% of the horizontal patients. Hypotension during the surgical procedure occurred in 26% and 22% of the sitting and horizontal

TABLE 2. Intraoperative Factors

	Sitting (n = 33)	Horizontal (n = 246)
Not different by position		
Hypotension with positioning	63 (19%)	60 (24%)
During procedure	86 (26%)	54 (22%)
Entire anesthetic (all patients)	121 (36%)	94 (38%)
Without cardiac disease	101/297 (34%)	130/197 (34%)
With cardiac disease	30/36 (56%)	27/49 (55%)
Different by position		
Transfusion over 2 units	3%	13%*
Average blood replacement	359 ml	507 ml†

* $P < 0.01$ by Chi-square.
† $P < .05$ by Student's t test.

TABLE 3. Tumor Histology

Tumor Type	Sitting (n = 333)	Horizontal (n = 246)
Ependymoma	14	2*
Astrocytoma	31	7*
Meningioma	25	21
Acoustic neuroma	66	56
Arnold-Chiari	21	6*
Metastasis	33	5*
Tic douloureux	20	63*
Other (including aneurysm, AVM abcess, medulloblastoma, etc.)	123	86

* $P < 0.05$ by Chi-Square test.

patients, respectively. Hypotension throughout the entire anesthetic from induction through emergence was not different by position. Multivariant analysis controlling for the difference in the incidence of preoperative history of cardiovascular disease between the two groups also revealed no significant difference in the incidence of intraoperative hypotension between the horizontal and sitting position patients. All episodes of hypotension responded to surgical stimulus, fluids, or vasopressors.

The incidence of venous air embolism in patients monitored with the Doppler was significantly greater in the sitting patients (45%) as compared to the horizontal patients (12%). Seventy percent of patients in the horizontal positions were not monitored with a precordial Doppler. The incidence of VAE of 12% reflects only those patients with Doppler monitoring. The incidence of hemodynamic changes occurring with venous air embolism was not different by position (17% in the sitting patients and 22% in the horizontal patients). Because only 30% of horizontal patients were monitored with a Doppler and 12% of these patients were diagnosed as having VAE, the number of patients at risk for hemodynamic instability associated with documented VAE is small, increasing the likelihood of type II statistical error. As a result, it is unlikely that any difference would achieve statistical significance. There were no recognized episodes of paradoxical air embolism.

Intraoperative requirement for transfusion of more than two units of blood was significantly greater in patients in the horizontal group occurring in 13% of those patients as opposed to only 3% of patients in the sitting group (table 2). Average blood replacement was statistically significantly less in the sitting patients (359 ml *versus* 507 ml in the sitting and the horizontal patients, respectively). The incidence of requiring blood transfusion was not different between groups (57% in the sitting group, 49% in the horizontal group).

Patients with astrocytoma, metastatic tumors, ependymoma, and Arnold-Chiari malformation were operated on significantly more frequently in the sitting position, while horizontal positions were utilized significantly more frequently for patients with tic douloureux. Meningiomas, acoustic neuromas, and other lesions were evenly distributed between the sitting and horizontal groups (table 3). Mean tumor size was similar in the two groups (2.6 cm in the patients in the sitting position group and 2.5 cm in the horizontal group). Mean duration of operation was not different between groups (5 h and 34 min in the sitting group and 5 h and 32 min in the horizontal group).

POSTOPERATIVE

Cranial nerve function at the time of discharge from the hospital was evaluated and the patients divided into three groups: those with improvement in cranial nerve function postoperatively, those with preservation of unchanged cranial nerve function, and those with deterioration of cranial nerve function. Improvement in cranial nerve function occurred significantly more frequent in the patients in the horizontal group (20% *versus* 12%). However, 26% of patients in the horizontal positions were undergoing microvascular decompression for tic douloureux. The preservation of unchanged cranial nerve function occurred significantly more often in patients in the sitting position (65% *versus* 45%), and deterioration of cranial nerve function occurred significantly more commonly in patients in the horizontal group (34% *versus* 22%). Multivariant analysis demonstrated a statistically significant relationship between pathology as well as position and cranial nerve function. After accounting for differences in cranial nerve function related to pathology, a significant difference in cranial nerve function between the horizontal and sitting groups is present, with patients in the sitting position having better function postoperatively. The occurrence of improvement or deterioration in mental status, cerebrovascular accident and onset of coma, seizures, or a somatic sensory or motor deficit was uncommon and not significantly different between groups (table 4).

The incidence of perioperative myocardial infarction was 0.3% in the sitting patients and 1.6% in the horizontal patients, and this difference did not achieve statistical significance ($P = 0.17$). Of the four myocardial infarctions occurring in patients in the horizontal group, two occurred intraoperatively and two during the first 72 h postoperatively. In the one patient in the sitting group suffering a perioperative myocardial infarction, it occurred in the first 72 h of postoperative period. Significant postoperative pulmonary problems were due to inability to protect the airway because of cranial nerve dysfunction with or without aspiration pneumonia or deterioration of poor preoperative pulmonary

function. This was not different by position occurring in 2% of the sitting patients and 3% of the horizontal patients. The occurrence of cardiopulmonary complications was examined in relationship to the occurrence of venous air embolism. None of the patients having venous air embolism suffered a perioperative myocardial infarction, and the occurrence of postoperative respiratory complications was the same in those patients with and without venous air embolism. There was no difference in the occurrence of postoperative congestive heart failure, pulmonary embolus, or hemodynamic instability between the groups.

There were no cases of quadriparesis, symptomatic pneumocephalus, peripheral nerve injury, or massive swelling of the face and neck in either group. The incidence of eye injury was not significantly different between groups. The incidence of surgical complications requiring re-exploration was low and not different by position. There was no difference in postoperative bleeding between groups. Acute mortality (within 30 days postoperatively) was not different by position (table 4). Seventy-six percent of patients in the sitting group and 60% of patients in the horizontal group were followed for more than 3 months postoperatively. Neurologic status in these patients at long-term follow-up was similar between groups. A higher percentage of the patients in the sitting group were dead at the time of last follow-up (14% *versus* 6%). However, more of the patients in the sitting group were operated on during the earlier years of the study period and, therefore, had a longer follow-up. A log rank test demonstrated no significant difference in survival by position ($P = 0.27$) (table 5).

TABLE 4. Postoperative Outcomes Not Different by Position

	Sitting (n = 333)	Horizontal (n = 246)
Mental status deteriorated	14 (4%)	9 (4%)
Mental status improved	7 (2%)	12 (5%)
Eye injury	8 (2%)	12 (5%)
Seizures	6 (2%)	2 (1%)
Motor deficit new or worse	17 (5%)	16 (6%)
Motor deficit improved	29 (9%)	9 (4%)
Sensory deficit new or worse	6 (2%)	5 (2%)
Sensory deficit improved	19 (6%)	4 (2%)
Complete loss of facial nerve function	23 (7%)	26 (11%)
Perioperative MI	1 (0.3%)	4 (1.6%)
Respiratory complications	7 (2%)	8 (3%)
Coma (>1 week)	6 (2%)	3 (1%)
CVA	8 (2%)	8 (3%)
CHF	1 (0.3%)	0
Hemodynamic instability	5 (1.5%)	10 (4%)
Pulmonary embolus	0	2 (1%)
Re-exploration for bleeding	6 (1.8%)	6 (2.4%)
Re-exploration for infection	2 (0.6%)	2 (0.8%)
Acute mortality (within 30 days)	9 (2.7%)	5 (2.0%)
Quadriparesis	0	0
Symptomatic pneumocephalus	0	0
Peripheral nerve injury	0	0
Laryngeal or lingual edema	0	0

Discussion

Several major series examining the sitting position have recently been published.[1–5] However, none of these series compared the sitting position to the alternative horizontal positions. In order to make recommendations regarding the continued use of a given practice, it is appropriate to compare that practice to its alternatives. This series of 579 posterior fossa craniectomies performed over a 4-y period provides a unique opportunity to compare outcome between those patients operated on in the sitting and horizontal positions. Interpretation of these data must take into account the major limitations of this study; specifically, that it is retrospective and non-randomized. As a result, there are statistically significant differences between patients in the two groups other than surgical position. In addition, more patients in the sitting group were operated on in the first half of the study period. Although our anesthetic practice changed little over this 4-y period from 1981 through 1984, new drugs, such as the calcium channel blockers and isoflurane, came into common clinical use. In spite of these limitations, useful insight can be gained from a detailed review of a large series of posterior fossa craniectomies. A prospective study in which surgical position is assigned randomly would further define risks and benefits associated with the sitting and horizontal positions.

Venous air embolism is a frequent event in patients undergoing posterior fossa procedures while in the sitting position, occurring in 45% of patients in this series. This is comparable to the incidences reported by Matjasko *et al.*[2] and Young *et al.*[5] for posterior fossa craniectomies in the sitting position. However, use of the horizontal positions did not eliminate the risk of VAE, which occurred in 12% of patients in the horizontal group monitored with precordial Doppler. This, too, is similar to an 11% incidence of VAE reported for pa-

TABLE 5. Status at Long-term Follow-up

	Sitting	Horizontal
Neurologically normal	56%	55%
Neurologic deficit, but functioning well	25%	31%
Neurologically disabled	6%	8%
Dead	14%	6%

No values are statistically significantly different by position.

tients undergoing a variety of procedures while in the horizontal position.[4] Once VAE occurred, the incidence of hemodynamic changes during VAE was not different between the groups and similar to that reported by others in recent series.[1-3,5] The advent of routine Doppler monitoring has allowed for earlier detection and treatment of VAE and a much lower incidence of hemodynamic instability with VAE (about 20% in recent series) than reported in earlier series.[6] There were no episodes of clinical paradoxical air embolism in our study, and this is comparable to the very rare occurrence of this complication reported in other series.[1-3,5] Importantly, there was no morbidity or mortality attributed to VAE in this series. Although the occurrence of VAE is an important consideration during posterior fossa surgery, current methods of monitoring for VAE with precordial Doppler and end-tidal CO_2 allow for early detection, prompt therapy by the anesthesiologist, and elimination of the source by the surgeon. This has resulted in a reduction in the occurrence of hemodynamic instability with VAE, and nearly eliminated morbidity due to VAE.

Proponents of the sitting position suggest that it results in decreased blood loss. These data support that clinical impression, showing a lower incidence of requirement for transfusion of large volumes of blood, as well as a lower average blood replacement for patients in the sitting position.

A reason often given for avoiding the sitting position is an increased occurrence of hemodynamic instability. Hypotension occurred in 19% of the sitting patients during positioning, and this is within the range of that reported in other series examining the sitting position.[1,2,5] However, this incidence was no different from the incidence of hypotension during the same time period in the horizontal group. One factor to be considered when evaluating the incidence of hypotension with positioning is the use of the pinion head holder. All patients to be placed in the sitting position had pinions applied just prior to being placed in the sitting position. This stimulus was present in some, but not all, patients in the horizontal group, and could be responsible for limiting the degree of hypotension in some patients. There was also no difference in the incidence of hypotension during the surgical procedure between the two groups. The significant difference in the incidence of cardiovascular disease between the two groups would be expected to influence the incidence of intraoperative hypotension. It is possible that the failure to demonstrate a higher incidence of intraoperative hypotension in patients placed in the sitting position is due to the lower incidence of cardiovascular disease in patients in the sitting group. However, multivariant analysis controlling for the presence of cardiovascular disease also failed to demonstrate any difference in the incidence of hypotension between the horizontal and sitting positions. It would seem unlikely that the lower incidence of cardiovascular disease in patients in the sitting position group explains the lack of an increased incidence of hypotension in the sitting position.

There are reports demonstrating possible adverse hemodynamic changes occurring with assuming the sitting position in the absence of arterial hypotension, such as decreased stroke volume, cardiac index, and central venous pressure, increased systemic vascular resistance,[7,8] and decreased cerebral blood flow.[9] If the sitting position does impose increased cardiovascular risk on patients, one might expect, in a series of this size, to see a higher incidence of perioperative myocardial infarction or cerebrovascular accident in the sitting group. However, there was no difference in the incidence of myocardial infarction between the two groups. The very low incidence of perioperative myocardial infarction is similar to other series of sitting cases.[2,5] There are significant differences between the sitting and horizontal patients, with the horizontal patients having a higher mean age (49 yr *versus* 42 yr) and a higher incidence of some manifestation of cardiovascular disease. Any conclusions drawn concerning the incidence of perioperative myocardial infarctions must take into account these differences. Because of the very low incidence of myocardial infarction, any multivariant statistical analysis attempting to account for the differences in cardiovascular history would not demonstrate a significant difference in the incidence of perioperative myocardial infarctions between positions, even if it does exist. Patients with prior myocardial infarction and angina were operated on in the sitting position. None of these patients suffered a perioperative myocardial infarction, suggesting that the sitting position can be used safely in this group of patients. The occurrence of perioperative cerebrovascular accident was rare, and was not different between positions. The low incidence of respiratory complications found in both groups is similar to other recent series.[3,5] These data do not support the assumption of an increased risk of cardiac or respiratory complications associated with use of the sitting position.

Caution must be exercised in interpreting these data, because there are important differences in the cardiovascular history between patients operated on in the horizontal and sitting positions. These data do not suggest that the sitting position (or horizontal position) in neurosurgical patients is free of risks for intraoperative cardiovascular stress or instability. The lack of difference in the incidence of intraoperative hypotension between the groups, even when accounting for the difference between the groups in incidence of cardiovascular

disease and the use of the sitting position in patients with known coronary artery disease without the development of a perioperative myocardial infarction, are encouraging. These observations suggest that, whatever the cardiovascular risks inherent to the sitting position, its use is not prohibited even in selected patients with known cardiovascular disease.

It is difficult to evaluate the adequacy of surgical exposure in the patients in the two positions. Operative time was not different by position. To evaluate the surgeon's subjective impression of the ease or difficulty of the surgical procedure, the operative dictation of each case was reviewed. Technical problems were noted by the surgeon in procedures performed in both positions. Although there were several types of technical difficulties mentioned (table 6), the one commented on most frequently was difficulty controlling bleeding, which referred not necessarily to large volumes of blood loss, but to bleeding that occurred during a crucial point in the operation or in close proximity to a critical structure. This occurred in 30 of the horizontal patients and 14 of the sitting patients. No statistical analysis was carried out on these subjectively arrived at data.

Perhaps the best evaluation of surgical exposure is neurologic outcome. Because neurologic outcome is more likely related to pathology and size of the lesion, the patients were divided into groups based on the type of lesion. Within each subgroup, patients in the sitting position had significantly better cranial nerve function postoperatively. Although it is difficult to relate preservation of cranial nerve function solely to surgical position, these data do suggest that the sitting position is at least as good as the horizontal position in allowing for preservation of cranial nerve function. The sitting position provides the advantage of allowing observation of the face for indication of surgical stimulation of cranial nerves, providing warning to surgeons that they are near vital structures. This may become of less importance as intraoperative monitoring of facial electromyography and brainstem auditory evoked potentials becomes more common.

Other reasons cited for avoidance of the sitting position include the risk of quadriparesis,[10] increased risk of tension pneumocephalus,[11,12] and postoperative bleeding.[13] Kurze collected a total of 29 cases of quadriplegia occurring following procedures performed in patients in the sitting position by requesting information on these cases worldwide. In addition, three unsolicited cases of quadriplegia following procedures performed on patients in the horizontal position were reported to him.* Standefer *et al.*[3] and Matjasko *et al.*,[2] in large series, each reported one case of neurologic deterioration following procedures in patients in the sitting position that involved surgical manipulation in the area of the cervical cord. Neither group reported a case of quadriplegia following posterior fossa procedures in patients in the sitting position. Young *et al.*[5] reported one case of triparesis following resection of an acoustic neuroma in a patient in the sitting position. Quadriparesis, which did not occur in our series, is indeed a rare complication, felt by Wilder to be related to excessive flexion of the neck.[10] It is known to occur in positions other than the sitting position, and perhaps can better be avoided by careful positioning rather than avoidance of the sitting position. Tension pneumocephalus and postoperative bleeding requiring re-exploration are uncommon and not different by position in this series. Lingual and laryngeal edema have been reported following procedures in the sitting position.[14,15] This problem is not unique to the sitting position, and was not encountered in this series. Peripheral nerve injuries have also been reported following cases in patients in the sitting position,[3] and, again, are not unique to the sitting position and can be avoided by careful positioning. Neurologic status at long-term follow-up and survival were not different between groups.

TABLE 6. Intraoperative Surgical Events (From Operative Dictation)

	Sitting (n = 333)	Horizontal (n = 246)
Bleeding (difficult to control)	14	30
Compromised exposure	6	6
"Tight brain"	5	3
Aneurysm rupture	0	3
Position change	2	1
Edema	12	7

There is no one best surgical position for all patients requiring surgical exploration of the posterior fossa. As demonstrated by the considerable controversy surrounding this issue, there are significant advantages and disadvantages to both sitting and horizontal positions. Appropriate management of patients requiring posterior fossa craniectomy requires consideration of advantages and disadvantages of both positions as they apply to an individual patient to select the position most appropriate for that patient, as well as for physicians providing care. These data suggest that both the sitting and horizontal positions can be used safely in a wide variety of patients, and that selection of position based on surgical considerations, as is the practice at our institution, does not increase overall risk to patients as measured by outcome.

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