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"I would have everie man write what he knowes and no more."—Montaigne

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Editorial I

The sitting position in neurosurgery—not yet obsolete!

The 1960s and the 1970s were the heyday for the popularity of the sitting position for surgical procedures involving the cervicodorsal spine and the posterior and lateral cranial fossae.[1] This patient position provides optimum access to midline lesions, improves cerebral venous decompression, lowers intracranial pressure (ICP), and promotes gravity drainage of blood and cerebral spinal fluid (CSF).[2] Accumulated blood drains out of and away from the operative site in the sitting position, permitting more rapid access to bleeding points, a cleaner surgical field and a technically easier procedure than is possible in the prone position. In addition, the sitting position provides an unobstructed view of the patient's face, enabling observation of motor responses to cranial nerve stimulation. In some procedures, notably supracerebellar, infratentorial approaches to the pineal gland, the sitting position minimizes the amount of cerebellar retraction needed to gain access to deeper structures. Complications related to the use of this position include haemodynamic instability, venous air embolism (VAE) with the possibility of paradoxical air embolism, pneumocephalus, quadriplegia, and compressive peripheral neuropathy.[3]

Although there have been a number of studies substantiating the relative safety of the sitting position for neurosurgery, its use remains controversial and appears to be diminishing because of the potential for serious complications and malpractice liability claims. Alarming reports of postoperative quadriplegia in young patients,[4 5] and successful malpractice liability claims arising from neurological dysfunction secondary to paradoxical air embolism (PAE) (J. D. Michenfelder, personal communication), has resulted in a dramatic decline in the UK and in the US in the use of the sitting position for neurosurgery. Campkin and colleagues[6] reported that 19 (53%) of the 36 UK neurosurgical centres surveyed in 1981 used the sitting position for posterior fossa surgery and 11 (30%) for cervical spinal surgery. Elton and Howell[7], based on a postal survey of UK neurosurgical centres, claimed a greater than 50% reduction in the number of neurosurgical centres using the sitting position during the decade, 1981–1991. In 1991, patients were normally placed in the sitting position for posterior fossa surgery in eight (20%) of the UK centres surveyed compared with 19 (53%) in 1981. Black and colleagues[8] also reported a major change from sitting to horizontal position for patients undergoing posterior fossa craniotomies over the 4-yr period from 1981–1984 at the Mayo Clinic. Posterior fossa craniotomies performed in the sitting position in that institution declined from over 110 per yr in the early 1980s to less than 50 by the mid decade. Responses to a recent questionnaire issued to 61 Japanese neurosurgical institutions reflects a similar decline with only 11.5% of centres reporting continued use of the sitting position.[9] As neurosurgeons abandon its application, it is likely that this trend will continue, as trainees in neurosurgery are not exposed to the relative merits of sitting position surgery.

Will specific difficult surgical access cases be denied the technical advantages of the sitting position in the future? Is the increasing preference for use of horizontal positions for surgical access to the posterior fossa appropriate, or should limited use of the sitting position remain in the neurosurgeon's armamentarium? Large prospective randomized controlled trials examining outcomes following neurosurgical procedures performed in the sitting compared with the prone or lateral positions are now unlikely to be undertaken. Current best available evidence is largely derived from data published following retrospective observational studies.

Harrison and colleagues report their experience of the use of the sitting position in 407 paediatric neurosurgical procedures performed over a 16-yr period at the Great Ormond Street Hospital for Children, London in this issue of the Journal.[10] This large retrospective observational study focuses on the incidence of VAE in this paediatric population, and on the important clinical issue of subsequent patient outcome. The authors report a low incidence of both VAE (9.3%) and associated postoperative morbidity, and they advocate the continued use of the sitting position in selected paediatric neurosurgical cases. The impressively low incidence of capnography-detected VAE in this Great Ormond Street paediatric series was remarkable considering the institution's minimalist intervention policy in terms of preoperative contrast echocardiography, central vein cannulation and use of anti-gravity suits. However, retrospective studies, such as this, rely on the accuracy of clinical detection and recording, and they may underestimate the true incidence of VAE. Despite such

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limitations, this observational study provides a significant body of data on the incidence and outcome of VAE in children. Duke and colleagues recently retrospectively reviewed morbidity related to intraoperative VAE in the sitting compared with supine position in 432 consecutive adult neurosurgical procedures performed at the Mayo Clinic.[11] Although the incidence of VAE detection in seated patients was higher (28 *vs* 5%), there was no significant difference in morbidity related to VAE.

Assessment of the relative risk-benefit of sitting position surgery for the individual patient, based on physical status and specific intracranial pathology is, therefore, of paramount importance. Appropriate patient selection, anticipation of potential complications and careful perioperative monitoring facilitate safe use of the sitting position. Preoperative contrast echocardiography is frequently performed for identification of patients at risk of PAE due to the presence of a patent foramen ovale (PFO). Weihs and colleagues[12] detected a PFO in 28% of a series of 165 adult neurosurgical patients using preoperative contrast echocardiography, which concurs with the findings of a large autopsy series which found an incidence of asymptomatic probe-patent PFO of 27%.[13] Using preoperative Doppler colour-flow imaging, in 30 children undergoing sitting position surgery, Fuchs and colleagues reported a PFO detection rate of 20%.[14] Although transoesophageal echocardiography (TOE) is currently the most sensitive monitoring device, its sensitivity in detecting PFO is not absolute,[15] and PAE has occurred despite absence of an interatrial connection on preoperative testing.[16]

The preoperative identification of a PFO has significant implications for subsequent patient management. We and others consider the preoperative presence of a PFO to be an absolute contraindication to sitting position surgery in view of the risk of PAE.[1 17] In contrast, Duke and colleagues using TOE imaging detected a PFO intraoperatively in 14% of 126 sitting position patients, and report that although the surgical position was not changed, PAE was not detected in any patient.[11] Practices vary regarding the routine preoperative screening of children for PFO prior to sitting position surgery. Preoperative screening was not performed in the series reported by Harrison's group[10] and although the authors advocate the safety of the sitting position in children based on their experience, extreme caution is advised in considering use of this surgical position in children potentially at risk of PAE.

The reported incidence of VAE associated with sitting neurosurgical procedures varies considerably, ranging from 25%[18] to 76%[17] depending on the sensitivity of the monitoring modality used. Monitoring techniques include capnography, precordial Doppler, TOE, fractional excretion of nitrogen, oesophageal stethoscope, and transcutaneous oxygen measurement.[1] Transoesophageal echocardiography is the most sensitive monitor to detect air in the right atrium and paradoxical embolisation to the left atrium through a PFO.[19] A prospective study to determine the clinical significance of small numbers of intracardiac microbubbles detected by TOE may be difficult. Mammotto and colleagues[20] prospectively graded the severity of TOE-detected VAE using a microbubble score (grade 0–3) in 21 patients undergoing sitting position surgery. VAE was detected in all patients. However PAE occurred only after the most severe grades of VAE (grades 2–3).

The oesophageal stethoscope has traditionally been used for diagnosis of VAE. However detection of a 'mill-wheel' murmur is dependant on large volumes of intracardiac air and, therefore, provides little advance warning of impending cardiovascular collapse. Precordial Doppler ultrasonography is the most sensitive of the generally available monitors capable of detecting intracardiac air.[20 21] The pulmonary artery catheter has been evaluated as a diagnostic tool for VAE detection.[22] An increase in pulmonary artery pressure provided a semi-quantitative estimate of the volume of intravascular air. The progressive decrease in lung perfusion caused by air within the pulmonary circulation leads to increased physiological deadspace, which is reflected by a decrease in end-tidal carbon dioxide concentration (E'_{CO_2}), and an increase in end-tidal nitrogen. Continuous E'_{CO_2} monitoring offers intermediate sensitivity with respect to VAE detection.[1] In the series reported by Harrison and colleagues,[10] capnography was used routinely for detection of VAE, with every fall from baseline E'_{CO_2} of $\geq$0.5 kPa recorded as an episode of VAE, whether or not there was any associated cardiovascular instability. The use of capnography, a less sensitive monitoring modality for VAE detection, is likely to have contributed to the finding of a lower incidence of VAE (9.3%) in this series than has been previously reported in adult,[17 20] and paediatric studies[14] using Doppler and/or TOE monitoring.

As no single monitor is completely reliable, use of more than one monitoring modality for VAE detection during sitting position surgery is recommended. Black and Cucchiari[2] recommend a minimum of three monitoring techniques. Placement of a multi-orificed central venous catheter is strongly recommended as a means of aspirating air from the circulation should embolism occur.[22] The junction of the superior vena cava and right atrium is the optimal catheter tip position for maximal efficacy in aspirating air.[23] A number of catheter localization techniques have been described, with the electrocardiographic guided technique[24] and TOE guided placement[25 26] allowing precise catheter positioning.

Harrison and colleagues large paediatric series in this journal issue focused on the important clinical issue of patient outcome following VAE. Associated hypotension occurred in only 2% of the 407 procedures, and the authors reported no perioperative morbidity related to VAE, apart from mild hemiparesis in two patients. Black and colleagues[8] retrospectively reviewed 579 posterior fossa craniectomies performed in either the sitting (n=333) or horizontal position (n=246). VAE occurred significantly more often in the sitting position (45 *vs* 12%). However, no morbidity or mortality was attributed to air embolism. Similarly Matjasko and colleagues,[27] in a review of 554 patients, reported a low overall morbidity (1%) related to the sitting position, with 0.5% attributed to VAE. Duke and colleagues[11] reported a 28% incidence of VAE in the sitting position in a retrospective comparison with the supine position in 432 consecutive schwannoma resections. Postoperative VAE-related morbidity occurred in only one of 222 sitting patients (0.5%).

The low reported morbidity due to VAE in reported retrospective studies might lead to the conclusion that, although venous air emboli occur, they frequently have no serious consequences. However, equally it may be argued that the close vigilance exercised, and sensitive monitoring devices used during sitting position surgery result in early diagnosis and prompt treatment of VAE thus limiting the clinical sequelae. A prudent approach to minimizing the occurrence and consequences of VAE in seated patients should include appropriate patient selection based on individual risk-benefit analysis, preoperative screening to identify the population at risk of PAE, supplementary monitoring to promptly detect and treat VAE, and meticulous surgical technique to reduce venous air entrainment. This approach will allow selected patients to continue to benefit from the optimum surgical access and technical advantages of sitting position surgery.

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