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FORUM

The peri-operative complications of nasal intubation: a comparison of nostril side

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Summary

We studied 128 patients undergoing nasal intubation to see whether the nostril side used influenced peri-operative nasal complications. In the apparently normal nostril, there is no significant difference between either nostril in difficulty of intubation ($p > 0.8$). Similarly, there is no significant difference in the incidence of bleeding at intubation ($p > 0.2$), at extubation ($p > 0.5$) and once the patient has returned to recovery ($p > 0.1$). Postoperative nostril patency is also similar between groups ($p > 0.85$).

Keywords

Removal of the tube was performed with the patient reclined at 45°. The presence of blood at the external nares was observed as the tube was removed and also 10 min later in the recovery room. The patency of the nostril was also assessed at this stage by asking the patient to breathe through the intubated nostril whilst occluding the other. The patency was described as (1) fully patent, (2) partially obstructed or (3) completely obstructed.

Patient characteristics were analysed using the paired *t*-test and non-parametric data were analysed using the Chi-squared test. A p-value < 0.05 was taken as significant. Previous work has established an approximate overall bleeding rate of 10% for right-sided intubations. Our statistical analysis showed that a sample size of 64 in each group would allow detection of a doubling in bleeding rate between the two groups with a power of 90% at 5% significance.

Results

The patient characteristics are shown in Table 1. There were no significant differences between the two groups.

The incidences of difficulty with intubation are shown in Table 2. There was one failure to pass the tube through the nostril in each group. No further analysis of these subjects was made. The incidences of bleeding at intubation, extubation and in recovery are shown in Table 3. The degrees of nostril patency in recovery are shown in Table 4.

There was no evidence of any relationship between nostril side and incidence or severity of bleeding ($p > 0.2$ at intubation, $p > 0.5$ at extubation and $p > 0.1$ in recovery). No patient in either group needed specific treatment for epistaxis at any time. There was no evidence of any significant difference in difficulty of passing the tracheal tube through either nostril ($p > 0.8$) nor in nostril patency postoperatively ($p > 0.85$).

Combination of the appropriate variables into a logistic regression model showed that bleeding or nostril patency could not be predicted by bleeding at an earlier stage (i.e. at intubation) or a difficult intubation.

Table 1. Patient characteristics (mean (SD) or ratio)

	Nostril side used	
	Left	**Right**
Age; years	27.9 (9.9)	31.9 (14.4)
Sex; M:F	30:33	27:36
Weight; kg	70.2 (15.8)	68.9 (12.6)
Height; cm	170 (10)	172 (9)
ASA; 1:2	52:11	50:13

Table 2. Incidence of intubation difficulty according to nostril side used

	Nostril side used	
	Left ($n = 64$)	**Right ($n = 64$)**
Easy	48	49
Difficult	15	14
Failed	1	1

Discussion

Our study has shown that in the apparently normal nose, there is no statistically significant difference in the incidence of bleeding when intubating through either nostril. In addition, intubation difficulty and subsequent postoperative nostril patency are not dependent on the nostril side used.

Prior to this study it had been assumed that the side of the bevel of the tracheal tube would be the important factor in causing a difference in complications. The causes of epistaxis during nasal intubation are multiple but epithelial stripping, especially over the middle turbinate or nasal septum, is common [5]. Unrecognised anatomical defects such as septal spurs or a deviated septum [6], not apparent from external inspection, may render the septal mucosa and vessels more liable to damage [7]. Polypectomy [4], turbinectomy [2–8] and adenoidectomy [9] by the nasal tube have all been described. With the left-sided bevel of the tube and the sharper tip on the right, the turbinates are more at risk of damage in the right nostril whilst the septum is more at risk in the left nostril. With the turbinates being more supple than the septum, it might be expected that more damage would be done on

Table 3. Incidences of bleeding according to nostril side used

	Nostril side used	
	Left ($n = 63$)	**Right ($n = 63$)**
At intubation		
absent	43	50
mild	12	10
severe	8	3
At extubation		
absent	42	45
present	21	18
In recovery		
absent	55	60
present	8	3

Table 4. Nostril patency in recovery according to nostril

	Nostril side used	
	Left ($n = 63$)	Right ($n = 63$)
Clear	51	52
Partially blocked	6	6
Fully booked	6	5

the left than the right. However, we have not been able to prove this.

Previous studies and reports have used larger diameter tubes than in our study and consequently our overall bleeding rate is less than in these studies. O'Hanlon *et al.* [10] used 7.5- or 8-mm internal diameter tubes with an 80% bleeding rate, whilst O'Connell *et al.* [11] used tubes with 6- to 8-mm internal diameters with a 43% bleeding rate. Although the larger diameter tubes are recommended for routine nasal intubation [1], it is the authors' normal practice to use the smaller sizes described in this study. Similarly, the softer type of tracheal tube material used in our study is different from that reported in one of the previous studies [9]. However, this type of material is recommended [5] because it is less traumatic. This may also have decreased the overall incidence of bleeding. It is possible that rotation of the bevel 90° anticlockwise may decrease bleeding further as neither septum nor turbinate would then be at risk. However, this is conjecture, as the manoeuvre has not been scientifically tested. The use of vasoconstrictor spray has been shown to decrease the incidence of bleeding [10] but, as this is not part of our routine practice, we did not use it in this trial. Indeed, the use of a vasoconstrictor with a larger tracheal tube [10] still produced a greater incidence of bleeding than in our study. Nasal dilatation before intubation has not been shown to reduce bleeding [12].

Epistaxis during nasotracheal intubation assumes different importance at the various stages of the procedure. At intubation, bleeding can be a nuisance during direct laryngoscopy, especially when it is severe. However, if fibreoptic intubation is being considered, any blood that pools in the pharynx may obscure the view. This may hinder intubation [13] or even make it impossible.

When the tube is being removed, bleeding from the nose into the pharynx is undesirable because it may cause airway obstruction. In our trial, it was not possible to evaluate postnasal bleeding because of dental packs and gum bleeding. The bleeding noted at the external nares on extubation may have come from the surgical site. However, there was no significant difference between the two nostrils. This contamination problem is present in most cases in which nasal intubation is used, for example in dental surgery. In such cases, when fibreoptic intubation via the nose is used, an increased bleeding risk from one nostril might become significant to airway management at extubation.

In the recovery room when the patient is awake, epistaxis is mainly an inconvenience. However, it may become significant if it is prolonged in an otherwise pain-free patient waiting to go home.

Despite the possibility of the tracheal tube being caught on different anatomical structures in the nose, we could not demonstrate that one nostril was more difficult to intubate than the other. Difficulty with intubation, including the presence of the probable turbinate 'cracking' noise, was not related to subsequent presence or severity of bleeding. This finding is consistent with work from an earlier study [11].

Blockage of one nostril postoperatively is probably of no clinical relevance but may cause some concern to patients. There was no association of patency with presence or severity of bleeding, nor with difficulty of intubation in either nostril. Indeed, anecdotal evidence shows that some patients breathe much more easily after nasal intubation, presumably as a result of a therapeutic dilatation of the nostril.

In conclusion, when considering which nostril to use for intubation, our study shows that either nostril can be used with similar peri-operative consequences.

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FORUM

Regional anaesthesia for limb surgery – before or after general anaesthesia A survey of anaesthetists in the Oxford region

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Summary

We conducted a postal survey of 221 anaesthetists in the Oxford region to determine their views and actual clinical practice regarding regional anaesthesia in adult patients undergoing limb surgery, when a combined regional and general anaesthetic was planned. Of the 162 respondents (73.3%), 142 (87.6%) regularly practised regional blocks for limb surgery in adult patients. For all the regional anaesthetic techniques in question, more anaesthetists felt it was safer to perform these blocks before induction of general anaesthesia than after induction. However, their actual practice varied markedly from their views, with more anaesthetists performing these blocks after general anaesthesia. Overall, trainees performed blocks before induction of general anaesthesia more often than consultants ($p = 0.047$).

Keywords *Anaesthetic techniques*: regional; epidural; spinal.

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It is common practice to combine regional and general anaesthesia. The combined approach has beneficial effects on haemodynamics, respiratory function, intestinal motility and postoperative stress [1]. In addition, regional anaesthesia decreases the intra-operative anaesthetic and opioid requirement [2], decreases blood loss [3] and may contribute to thromboprophylaxis [4]. There is controversy, however, as to whether regional anaesthetic techniques should be performed before induction of general anaesthesia or after the patient is anaesthetised. The benefits of performing regional blocks on anaesthetised adult patients and its counter-arguments have been debated recently [5]. A pilot survey in our department revealed that most anaesthetists felt that when combined regional and general anaesthetic techniques are used, the regional technique should be performed before general anaesthesia. However, in actual practice most of these anaesthetists performed regional blocks after inducing general anaesthesia. We felt that this distinction was important and hence conducted the following survey in the Oxford region to compare the views and actual clinical practice of anaesthetists.

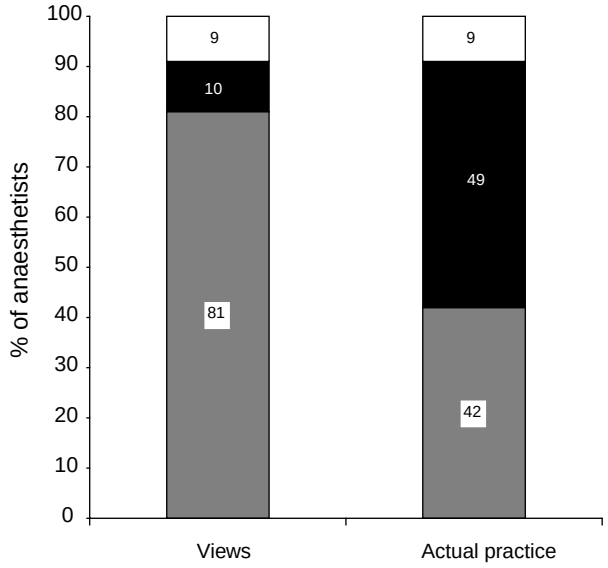

Figure 1 Anaesthetists' views and actual practice with regard to lumbar epidural block. White area, non-committed (not answered or not committed to one answer); black area, after general anaesthesia; grey area, before general anaesthesia.

Methods

A postal questionnaire was sent to 221 anaesthetists in the Oxford region. The questionnaire (copies are available on request from the authors) was designed in two parts. The first part was aimed at all respondents and included questions on whether anaesthetists felt it was safer to perform regional blocks before or after general anaesthesia, whether they regularly anaesthetised for limb surgery (plastics, trauma or orthopaedics) and the number of years in anaesthetic practice. The second part targeted those anaesthetists who regularly performed regional blocks for limb surgery in adult patients and asked them about the number of blocks they performed each week and their actual practice of performing these blocks. Data were analysed using the Chi-squared test; a p-value of < 0.05 was considered significant.

Results

Of the 221 questionnaires sent, we received 162 (73.3%) completed replies from 111 consultants, 30 specialist registrars (years 3–4) and 21 non-consultant career-grade anaesthetists. Data are presented for the 142 (87.6%) anaesthetists who regularly performed regional blocks for limb surgery in adult patients: 92 consultants, 30 specialist registrars and 20 non-consultant career-grade anaesthetists. The median (IQR [range]) length of time in anaesthetic practice was 18 (12–25 [6–40]) years for consultants, 7 (6–10 [5–15]) years for specialist registrars and 14.5 (10.75–19.75 [7–32]) years for non-consultant career-grade anaesthetists. Of these anaesthetists, 94 (66.2%) performed 1–3 regional blocks each week, 22 (15.5%) performed 3–5 blocks and 20 (14%) performed > 5 blocks each week (six anaesthetists did not answer this question).

One hundred and fifteen (81%) respondents felt that it would be safer to perform epidural blocks before general anaesthesia, although in practice only 60 (42%) did so (Fig. 1). One hundred and six anaesthetists (75%) felt it was safer to perform subarachnoid blocks before general anaesthesia. In practice, 63 (44%) anaesthetists performed these blocks routinely before general anaesthesia (Fig. 2). Ninety-nine respondents (70%) felt that it was safer to perform peripheral limb blocks with the patient awake. In actual practice, 32% or fewer, depending on the type of the block, routinely performed peripheral blocks before general anaesthesia (Fig. 3). All the respondents, except 4% of consultants, performed caudal blocks after induction of general anaesthesia. When all blocks were combined, trainees were more likely than consultants

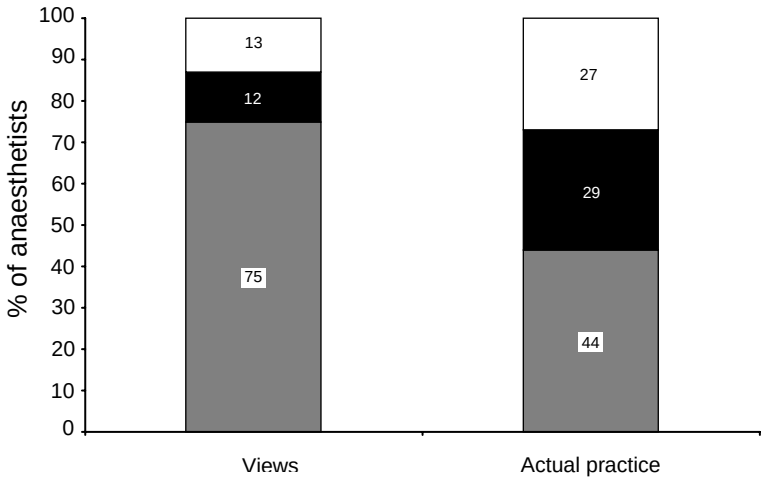

Figure 2 Anaesthetists' views and actual practice with regard to subarachnoid block. White area, non-committed (not answered or not committed to one answer); black area, after general anaesthesia; grey area, before general anaesthesia.

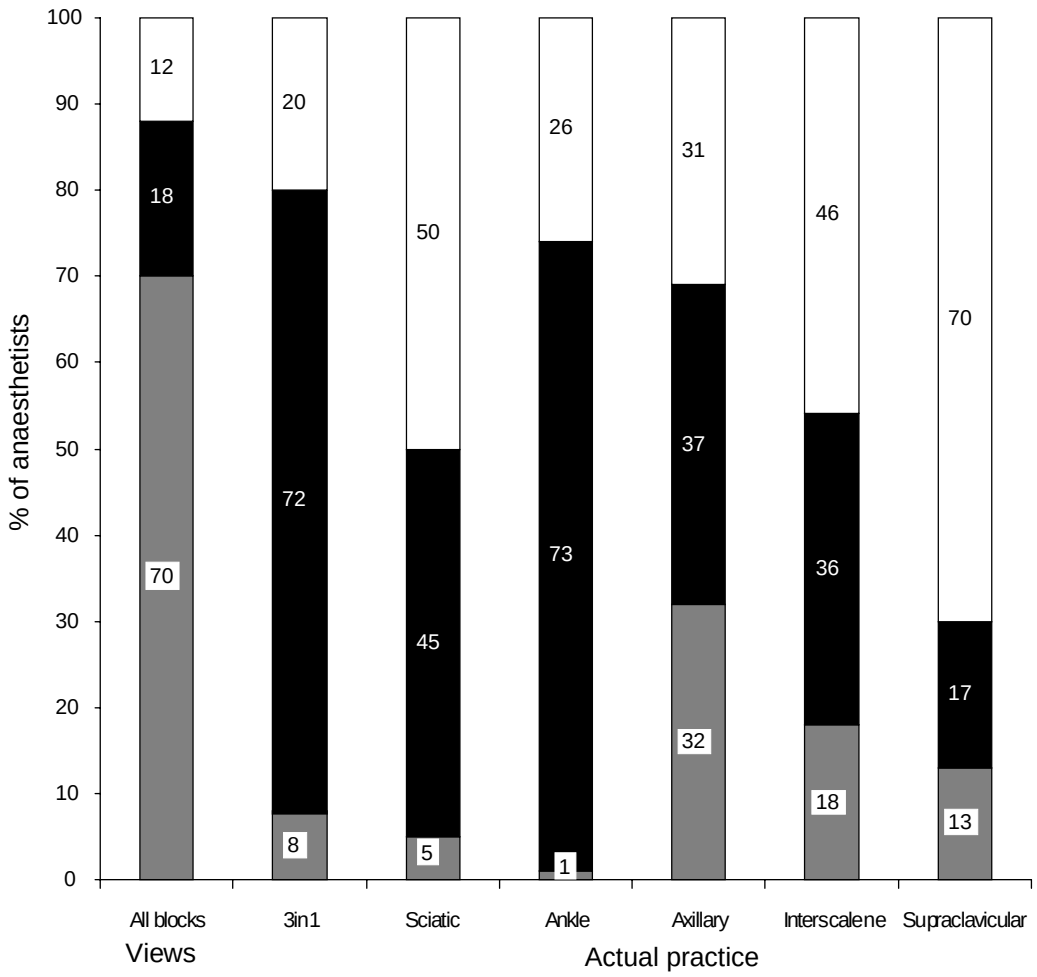

Figure 3 Anaesthetists' views (left) and actual practice with regard to peripheral blocks. White area, non-committed (not answered or not committed to one answer); black area, after general anaesthesia; grey area, before general anaesthesia.

(their trainers) to perform regional blocks before induction of general anaesthesia ($p = 0.047$).

Discussion

Discussion about the relative safety of performing regional blocks before or after induction of general anaesthesia has intensified recently in professional journals and at national and international anaesthetic meetings [5–8]. A possible explanation for such interest is the fact that, although serious complications are rare, they can be easily linked to needles and drugs [9].

The aim of our survey was to determine views regarding the safety of regional blocks performed during general anaesthesia, and compare them with actual practice. Our main target group was those anaesthetists who regularly performed regional blocks for limb surgery in adult patients. The results cannot necessarily be extrapolated to other types of surgery, for example, abdominal surgery.

The views of anaesthetists that regional blocks are safer when performed before general anaesthesia may be based on standard textbook teaching, views of medical experts, published qualitative studies and/or personal experience. A nightmare for any anaesthetist is to leave a previously neurologically intact patient damaged by one's needle, drug or other component of the technique. If this occurs, regional techniques are not always responsible for the neurological symptoms [10, 11] and even when they are implicated, other factors of substandard care are likely to contribute to the bad outcome [12, 13]. The safety of lumbar central blocks performed in anaesthetised patients has been questioned in recent closed claims studies [14, 15]. Auroy *et al.* [14] prospectively studied 103 730 regional anaesthetics and identified 34 serious neurological complications after spinal blocks; of these 21 (62%)

were associated with paraesthesia and in another nine (26%), 5% lidocaine was a possible damaging factor. Because of anatomical variations of usual surface landmarks [16], one can never be absolutely sure that the epidural or spinal needle is indeed inserted below the cord [17]. By preserving verbal contact with the patient, one might hope to be warned of the needle's misdirection [18] and thus avoid or limit the damage. Other advantages of regional blocks performed before general anaesthesia include the ability to test the block as well as to exclude intravenous, intrathecal or subdural injection.

Our survey confirmed the findings of our pilot study that although most anaesthetists felt regional blocks to be safer if performed before general anaesthesia, only about half of them actually did so. One possible explanation is that anaesthetists consider performing regional anaesthesia with the patient anaesthetised to be *safe enough*, because the risk of neurological complications is so low that it remains negligible. We cannot agree more with Fischer's statement that '…it is not the practice *per se* which is the risk factor, it is the standard to which it is performed' [19]. However, our surveyed anaesthetists may have felt that should complications ensue, especially nerve damage, a regional block is more likely to be blamed if it had been performed with the patient anaesthetised. This may have influenced the answers of anaesthetists to questions regarding their views. An interesting finding was that more trainees performed regional blocks before general anaesthesia than consultants. Our survey did not address the reasons for this finding, which could be the subject of further research.

Acknowledgments

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FORUM

Spinal endoscopy in chronic low back pain with radiculopathy A prospective case series

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Summary

All 38 patients listed for day-case spinal endoscopy over a 12-month period (April 1998 – April 1999), who had chronic severe low back pain with a radiculopathic element, were studied prospectively. The mean [range] pain duration before treatment was 10.9 [2–26] years and 50% had failed back surgery syndrome. In all patients in whom treatment was completed ($n = 34$), the pain-generating nerve roots were located through symptom interaction with the patient. All had epidural scar tissue, 14 (41%) having dense adhesions. Mobilisation of adhesions around the nerve root (neuroplasty) was performed so that a pocket was formed for the subsequent placement of bupivacaine, Depomedrone and clonidine. No intra-operative complications occurred and side-effects were minimal. Follow-up over a 12-month period showed statistically significant reductions in pain scores and disability. Spinal endoscopy may be the diagnostic method of choice for epidural fibrosis. It has substantial therapeutic and research potential. Prospective randomised studies are required.

Keywords *Pain*: chronic; sciatica. *Anaesthetic techniques*: epidural.

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Although most patients recover within 4 weeks of an episode of acute severe back pain with radiculopathic symptoms, up to 30% still have pain, a reduced capacity for work and a restriction in leisure activities at 1 year [1]. Chronic severe radiculopathic pain is difficult to manage and the outlook for these patients is not good. Spinal endoscopy using superfine, flexible and steerable instruments is a minimally invasive method of locating the exact nerve root or roots in the lumbosacral spine from which pain is arising. Adhesions around these nerve roots can be mobilised using the tip of the instrument, and medication can be applied accurately under direct vision. Outcome data on the efficacy of this undertaking are scant and no prospective randomised trials have appeared in the literature. This prospective cohort study comprises our first year of activity following the introduction of this new technology to our pain management clinic.

Methods

Over a 12-month period (April 1998 – April 1999), all patients with chronic low back pain with a radiculopathic element (pain with or without numbness, paraesthesiae or weakness in a single or multiple nerve root distribution) were studied (Table 1). All patients had had a poor response to primary and secondary analgesics, transcutaneous nerve stimulation and lumbar epidural steroids. All gave informed consent. The procedure was carried out as a day-case with light sedation so that co-operation could be assured. Under aseptic conditions, and with local anaesthesia (lidocaine 1%), the sacrococcygeal ligament was punctured with a 17 G Tuohy needle. Correct needle placement in the sacral canal was confirmed by injection of X-ray contrast medium (Isovist, Schering, Germany) and the epidurogram appearances following injection of

up to 10 ml of 1 : 1 diluted contrast medium in normal saline were recorded (Fig. 1). Using a Seldinger technique, an introducer sheath was advanced into the sacral epidural space. The spinal endoscope used is fully flexible and has an outside diameter of 0.9 mm, supplying a 10 000 pixel high-resolution image (Myelotec, Rosswell, USA). An outer steering sheath with a second injection lumen raised the total outside diameter to 2.2 mm. A standard light source and monitoring system was used (Karl Storz, Tuttlingen, Germany). The instrument was advanced gently and steered under direct vision, with radiological screening, towards the presumed site of origin of the patient's pain, as suggested by history and epidurographic findings (Figs 1 and 2). The exact site of pain generation was found through gentle contact with nerve roots until the patient reported pain replication. Adhesions that were in contact with this nerve root were mobilised using the tip of the spinal endoscope and a saline flow from the tip of the instrument (necessary to lubricate the instrument and optimise its focal length). Repeat epidurography was performed to assess the radiological effectiveness of this neuroplasty (Fig. 3, Table 2). Bupivacaine 0.25% 5 ml, Depomedrone 80 mg and clonidine 100 μg were accurately placed alongside the targeted nerve roots. At the end of the procedure, the patient was kept supine for at least 1 h and was discharged from hospital the same day.

Data collection included a pain severity score over 24 h as measured on a 10-cm visual analogue scale, with 0 cm representing no pain and 10 cm representing the worst pain imaginable. Functional activities were assessed using a Waddell and Main score [2]. Briefly, this involves a questionnaire in which one point is awarded for the ability to perform each of the following: heavy lifting, standing, walking, sitting and travelling, all for half an hour; lack of social and sex life restriction; putting on footwear and lack of sleep disturbance. Zero represents a severe functional restriction, whereas a score of nine

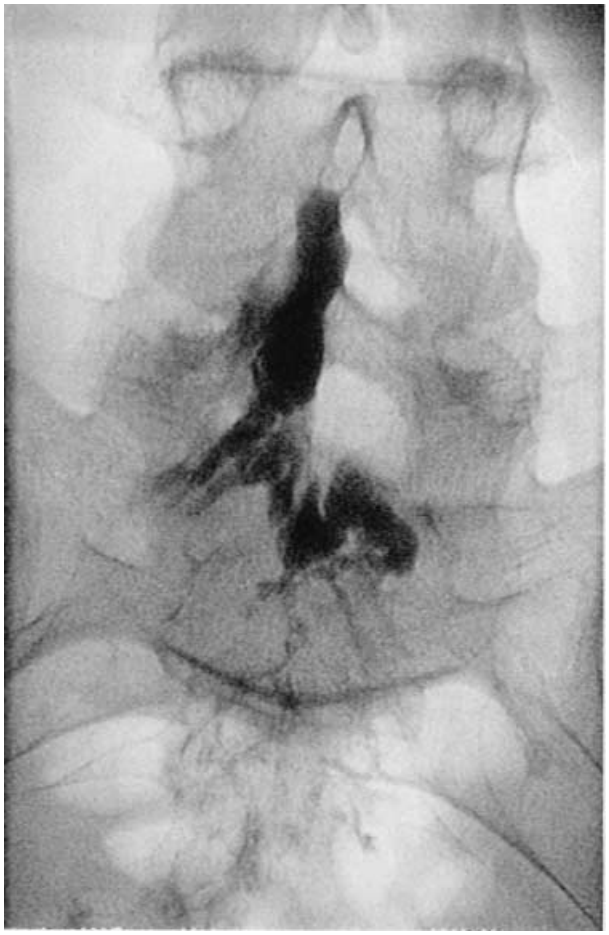

Figure 1 A pre-operative epidurogram of a patient who had undergone two previous discectomies along with 'packing' of the right-sided first sacral nerve root (S_1). She re-presented with right-sided radiculopathic symptoms and signs, predominantly in the S_1 distribution. Note the poor flow contrast through the intervertebral foramina on the right, along with a large filling defect.

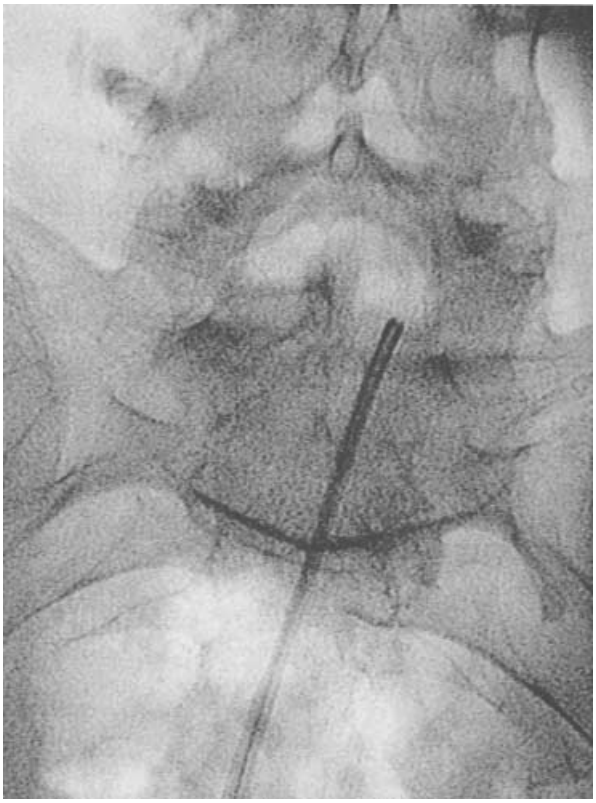

Figure 2 The spinal endoscope was steered up through the sacral hiatus into the filling defect on the right side where copious scar tissue was encountered.

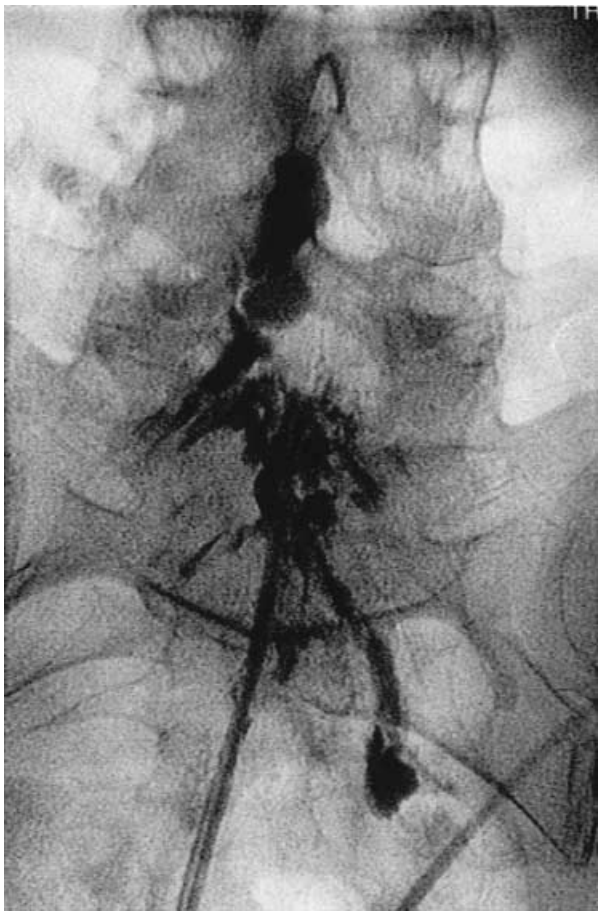

Figure 3 Post-procedure repeat epidurography in the same patient demonstrates that an effective right-sided adhesiolysis (neuroplasty) had been carried out, now with good flow of contrast along the S_1 nerve root. The large filling defect above this level remains, but as this was largely asymptomatic, it was left undisturbed.

indicates good function. These parameters were checked pre-operatively and postoperatively at 2, 6 and 12 months. In addition, a five-level satisfaction/dissatisfaction scale and a seven-level subjective improvement/deterioration scale were noted at 2 and 12 months.

Statistical analysis

Data were compiled using Microsoft EXCEL software. Statistical analysis was performed using SPSS Version 6 running in Windows 95. Non-parametric tests were used throughout and all repeat measures were subject to Kruskal–Wallis analysis of variance (ANOVA) as missing data resulted in unequal group sizes at different time intervals. Where pertinent, data at different time intervals were compared with that of the baseline controls using the Mann–Whitney *U*-test; Bonferroni corrections were applied to these results.

Table 1 Patient characteristics. Values are mean (SD) [range] where appropriate ($n = 38$).

Age; years	46 (12.6)
Sex, M: F	21 : 17
Symptom duration; years	10.9 (6) [2–26]
Radiculopathy present	18/38
Previous back surgery	19/38
Disc lesion present on imaging	23/38

Results

Thirty-eight patients were studied. All patients had pain that had arisen as a result of intervertebral disc disease, 19 (50%) of whom were classified as having a failed back surgery syndrome [3].

The procedure was aborted in four patients due to pre-operative lack of co-operation ($n = 2$) and inability to advance the introducer through the sacrococcygeal ligament ($n = 2$), hampered in one case by gross obesity. In all other patients, it was possible to steer the instrument to what was described as the exact site of origin of back and leg pain, which was found in all patients to be a nerve root or roots. The dermatomal level of this structure was suggested by history and abnormal epidurographic filling defects that corresponded with the symptoms in 27 (79%) patients. Gentle mechanical stimulation of this nerve root exactly reproduced the patient's pain. Fibrous adhesions onto the nerve root or surrounding this site were clearly seen in all patients, irrespective of previous back surgery (Figs 4 and 5). These were very dense in 14 (41%) patients (Fig. 5, Table 2). With movement of the instrument in order to examine this area, along with the constant saline flow, mobilisation of adhesions away from the nerve root was observed directly (a neuroplasty) and in some patients an increase in transmitted nerve root pulsation was observed. Post-procedure epidurography showed contrast flow through previously blocked intervertebral foramina

Table 2 Procedure data ($n = 34$).

Matching of preprocedure epidurogram filling defects with symptoms	27/34
Epiduroscopy finding	
Identification of pain generator	34/34
Adhesions	34/34
Dense fibrosis	14/34
Mean [range] duration; min	53 [42–85]
Post-procedure epidurogram improved	14/34
Intra-operative complications	None

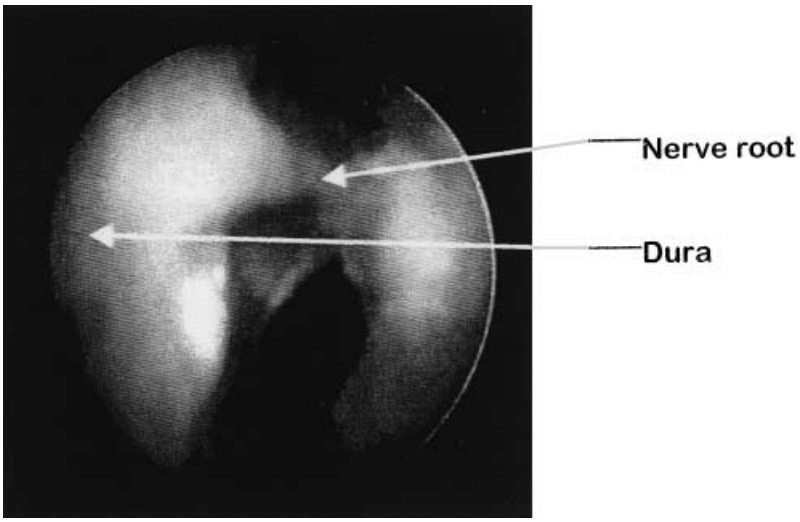

Figure 4 A normal nerve root emerging from the dura. Reproduced by kind permission of Myelotec Inc., Roswell, GA, USA.

in 14 (41%) patients (Figs 1–3). The mean [range] duration of the procedure was 53 [42–85] min.

Follow-up data were available for 27 patients at 2 months, 29 at 6 months and 26 at 12 months. Pre-operative pain severity scores over 24 h as measured on a 10-cm visual analogue scale were a median [range] of 8.2 [6.8−9.1], changing to 5.6 [0–8.7], 6.8 [4−8.7] and 6.7 [1.8−9] at 2, 6 and 12 months, respectively. The differences between these pain scores were statistically significant (Kruskal–Wallis ANOVA, $p < 0.0004$). This statistical significance remained even after Bonferroni correction of Mann–Whitney tests between baseline values and at 2, 6 and 12 months ($p < 0.001$). Figure 6 summarises these data.

Functional abilities (Waddel and Main score) showed very poor pre-operative abilities with a baseline median [range] of 1 [0–4]. Postoperatively, total function scores improved to a median of 4, 3 and 3 at 2, 6 and 12 months, respectively. These changes were statistically significant (Kruskal–Wallis ANOVA, $p = 0.0004$) and the improvement from baseline was maintained throughout the study period (Bonferroni corrected Mann–Whitney tests, $p < 0.0004$). Figure 7 summarises these changes.

In contrast, subjective measures of outcome changed little after treatment. Differences in the five-level satisfaction scores (0 = very dissatisfied, 4 = very satisfied) at 2 and 12 months did not reach statistical significance when the Mann–Whitney *U*-test was applied ($p = 0.9$). Similarly, seven-level scale measures for subjective improvement did not change significantly after treatment ($p = 0.17$) at either 2 or 12 months.

Side-effects encountered were some non-persistent postoperative low back discomfort in all patients. This was insufficient to require hospital stay and responded to

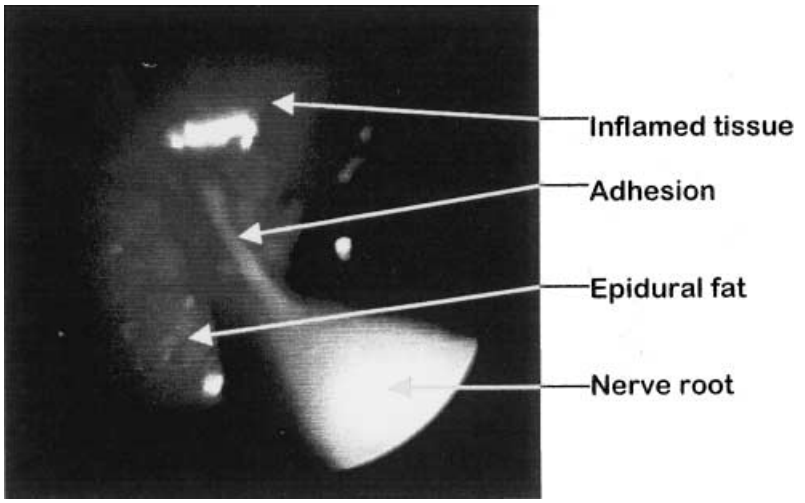

Figure 5 Typical spinal endoscopy findings in a patient with low-back and radicular pain. Note the firm adhesions to the nerve root. Reproduced by kind permission of Myelotec, Inc. Roswell, GA, USA.

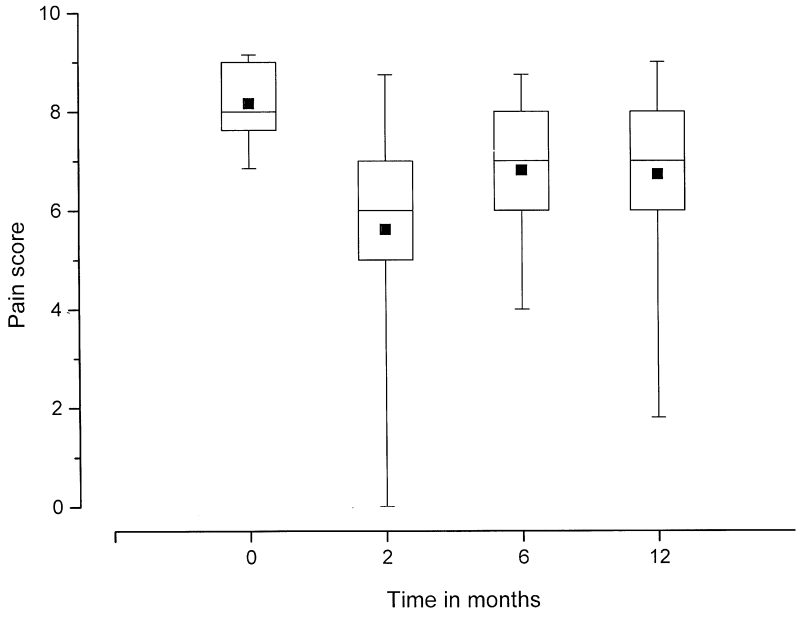

Figure 6 Box and whisker plot of visual analogue pain scores at 0, 2, 6 and 12 months. The black square indicates the median, the horizontal line the mean, the box represents interquartile range and the error bars indicate the range of values. Kruskal–Wallis ANOVA showed significant changes, $p = 0.0004$. Pain scores at 2, 6 and 12 months remained significantly improved compared with those at time 0. Bonferroni corrected p-values were 0.0004, 0.001 and 0.0006 when repeated Mann–Whitney tests were applied.

the patient's usual analgesic medication. Two patients had a two-day fluid leak of saline from the sacral hiatus and non-persistent paraesthesiae of the lower limb were generated in two patients. No dural tap was knowingly caused and no headaches ensued.

Discussion

In this prospective case series, we identified the exact site of pain generation, followed by nerve root adhesiolysis (neuroplasty) and very accurate placement of local anaesthetic, clonidine and steroid. A moderate but statistically significant reduction in pain and improved function was induced and maintained for 1 year. A number of questions is raised by these results, involving the proposed mechanism of action, safety aspects and the place of spinal endoscopy alongside traditional investigations and management.

The finding that all patients had adhesions between nerve roots, the dura, ligamentum flavum and the periosteum, being very dense in 14 (41%) (Fig. 5, Table 2), was striking. This suggests that gadolinium-enhanced magnetic resonance imaging, currently the investigation of choice for epidural fibrosis [4], produces a

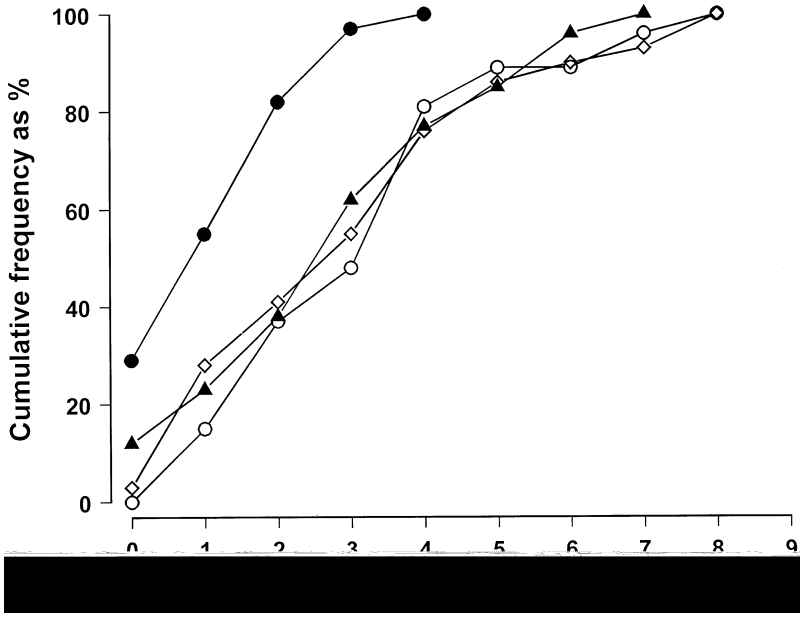

Figure 7 Cumulative frequency distribution of Waddel Main total function scores showing improved scores after treatment (Kruskal–Wallis ANOVA, $p = 0.0004$). Scores at 2, 6 and 12 months remain significantly better than before treatment even after Bonferroni correction of repeated Mann–Whitney tests. Scores before (●) and at 2 (○), 6 (□) and (▲) 12 months after treatment.

large underestimate of its incidence and extent. Fibrosis forms as a result of a chronic chemical radiculitis, neurogenic inflammation, a probable autoimmune response to nucleus pulposus and impaired fibrinolysis [5–11]. Surgery is a potent source of adhesions and, in our patients, was found to be associated with the densest fibrosis.

Adhesions surrounding nerve roots may interfere with their nutrition and blood supply [7] and are potent contributors to radicular pain [6, 7]. Blood supply to the nerve root, compared with the dorsal root ganglion, is poor, with ≈ 75% of nutrition depending upon a flow of cerebrospinal fluid (CSF) [12, 13]. In disease states, especially with adhesive arachnoiditis, nutrition of the nerve root becomes critical [7, 9, 12]. This may occur not just through mechanical constriction of the vessels, leading to intraneural oedema [7, 12], but also because of rapid thrombus formation in the intraneural capillaries, which has been shown to follow nucleus pulposus application [5, 9, 13]. Impairment of intraneural blood flow is probably the final common pathway leading to abnormalities in nerve conduction and pain generation [5, 9, 11, 13].

During the process of examination, the presence of the spinal endoscope adjacent to the nerve root, along with the saline flow, can be seen to mobilise adhesions and open up tissue planes (neuroplasty). The effectiveness of this process can also be observed indirectly, with preprocedure vs. postprocedure epidurography (Table 2, Figs 1–3). It is possible that adhesiolysis reduces pain generation through improvement in nerve root nutrition by removal of obstruction to blood supply and CSF flow. Nerve root electrophysiological dysfunction [5, 7–11] may therefore improve through reversal of ischaemia and restoration of adequate supply of nerve growth factor necessary for maintenance of myelin sheath integrity and electrical silence [14]. In earlier case series, marked symptomatic improvements have been observed in patients with adhesive arachnoiditis without the administration of any medication, simply through the process of examination [15, 16].

Dilution or 'washing-out' through intervertebral foramina of phospholipase A_2 and synovial cytokines, which are known to leak from damaged intervertebral discs and zygo-apophyseal joints [7, 10] may also contribute to an improvement in symptoms. This process may account for some confusion that has arisen in studies of epidural steroids when 'placebo' epidural saline groups do well [17, 18].

Spinal endoscopy allows for the accurate placement of epidural medications, in this case series Depomedrone, bupivacaine and clonidine. Elicitation of the exact pain-generating nerve roots is an integral part of the procedure, through interaction with the conscious patient. Contact with non-inflamed nerve roots produces surprisingly little discomfort as opposed to the exact reproduction of pain with gentle contact between the tip of the spinal endoscope and an inflamed nerve root. The ensuing mechanical and hydrostatic adhesiolysis effectively forms a pocket for the therapeutic solution (Fig. 3). Delivery of medication into this pocket facilitates the optimum possible benefit that can be derived from these medications.

The proposed benefits of targeted medication delivery can be contrasted with traditional 'blind' epidural injections. It has been estimated that in > 50% of patients, injections are outside the epidural space if radiological confirmation of needle placement is lacking [19, 20]. Even if needle tip position is satisfactory, solutions are injected some distance from the required site of action and spread will be determined by compliance gradients. Filling defects seen on injection of contrast medium often occupy a number of segments that usually include the pain generating nerve roots (Table 2, Figs 1 and 5). The route of spread of epidural solution is unlikely to be very different from that of contrast medium, which tends to be away from the target area because of fibrosis. Spinal endoscopy overcomes this mechanism. From the point of view of avoidance of complications from steroid injections, it is important to avoid intrathecal injection [21], and this is readily achieved with the aid of direct vision.

The use of clonidine may have influenced our results, but we doubt if this would be the case over the timescale of our follow-up. In the short-term, clonidine increases the intensity of nerve blockade with local anaesthetics, having particular effects on A delta and C fibres and is particularly effective in patients with neuropathic pain [22]. Even though its analgesic effect can outlast the effect of the local anaesthetic, its overall effects are probably no longer than 24 h [22].

Further mechanisms explaining our positive outcomes include a placebo response, or the possibility of a natural improvement without any form of intervention, although the duration of symptoms with regards to the latter, a mean [range] of 10.9 [2–26] years, would not suggest this process.

Our results were achieved at little cost in terms of side-effects, and no complications were generated, which is in agreement with the published literature. However, recently, three potentially lethal complications of 10 patient examinations have been reported [23]. These involved serious medulla-radicular irritation, resulting in seizures, bradycardia and respiratory depression requiring emergency drug treatment and assisted ventilation. These events probably resulted from the large volumes of epidural fluid that were used (up to 1200 ml), as well as heavy sedation [24]. Excess epidural pressure is transmitted throughout the

neuraxis via the hydraulics of the CSF [25]. The resulting intracranial pressures would have been very high. In our examinations, lasting ≈ 1 h, we used ≈ 100 ml of saline.

The greatest safety feature remains the patient's symptoms; it is essential to maintain appropriate verbal contact at all times. This not only ensures that pain-generating nerve roots can be distinguished from non-painful nerve roots, but also that the saline flow can be slowed or stopped immediately upon reported adverse symptoms, e.g. headache, 'pressure' in the low back or paraesthesiae.

Our failure rate for procedures in this series was 11% (4/38). Since these early failures (within the first 10 patients), we have found it impossible to proceed in only one other patient. Entry through the sacrococcygeal ligament is facilitated by the use of lateral radiological screening, which is especially helpful in the obese.

In this non-controlled, prospective study of 38 patients, we effected a moderate, but sustained, reduction in long-term chronic radicular pain and an improvement in disability. Only minor side-effects ensued and no complications were generated. Spinal endoscopy with modern equipment appears to be the diagnostic method of choice for epidural fibrosis. It has great teaching, research and therapeutic potential [26]. Prospective randomised studies are required.

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FORUM

Intravesical pressure and the TUR syndrome

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Summary

Intravesical pressure was measured continuously during 35 transurethral prostate resections using a fine suprapubic catheter. Absorption of irrigating fluid was detected by tagging it with ethanol and sampling the expired breath using an alcohol meter. Higher mean (SD) intravesical pressure was demonstrated in those patients who absorbed irrigating fluid (19.1 (7.7) mmHg) than in those who did not (12.4 (6.5) mmHg; $p = 0.00004$). Higher peak pressures were also demonstrated among absorbing patients. Traditional risk factors for fluid absorption, such as operator experience and resectate mass, were found to correlate with pressure exposure over time. Exposure to supranormal bladder pressure over time is the final common path for all causes of absorption. Vesical pressure monitoring may be a valuable feedback tool during difficult resections or operator training.

Keywords *Prostate*: transurethral resection. *Complications*: TUR syndrome.

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The problem of irrigation fluid absorption during transurethral resection of the prostate gland (TURP) was first reported in 1947. Peri-operative haemolysis and fluid absorption were the concerns of the earliest investigators [1, 2]. Irrigant absorption may occur in up to 46% of resections [3] with 5–10% of patients absorbing 1 litre or more [4, 5].

Landsteiner & Finch [2] recognised, as early as 1947, the importance of excessive intravesical pressure to the risk of fluid absorption. Vesical pressure limitation by the use of a pressure alarm device [6] and by calibrated measurement through the resectoscope [7] has reduced absorption but not prevented it completely. Using the absorption detection technique suggested by Hulten *et al.* [8] and subsequently refined by Hahn in 1993 [9], Checketts & Duthie [4] suggested that overfilling and high bladder pressures were major factors in the tendency to irrigant absorption when the operator was a trainee.

We hypothesised that intravesical pressure is the final mechanism by which irrigating fluid is absorbed and that the pattern of pressure exposure is important. By studying bladder pressure during surgery, we aimed to identify pressure patterns that would minimise the risk of absorption. Using such information, vesical pressure analysis could influence operating technique with a view to prevention of the absorption syndrome.

Methods

Local ethics committee approval and written, informed patient consent were obtained. Thirty-five patients were studied, as determined using a recognised power nomogram [10]. This number of subjects gave a power of 85% in detecting a difference of one estimated SD of vesical pressure between absorbers and non-absorbers of irrigation fluid. Patients were not studied if known or suspected to be alcohol sensitive or if unable to provide informed consent. As it was considered unethical to randomly allocate patients to receive high intravesical pressure during resection,

patients were stratified post hoc on the basis of whether irrigant absorption was detected during the study.

Following premedication with oral temazepam 10–20 mg, spinal anaesthesia was established using 2.5–3 ml of hyperbaric 0.5% bupivacaine. Conscious sedation was maintained intra-operatively with small intravenous boluses of midazolam. Systolic arterial pressure was maintained within 20% of pre-operative values using an intravenous infusion of Ringer's lactate and small intravenous boluses of ephedrine or methoxamine. Irrigating fluid was a commercial solution of glycine 1.5% and ethanol 1% (Baxter Healthcare Ltd, Thetford, UK). Fluid height was maintained 90 cm above the pubic tubercle and a continuous-flow resectoscope system was used with suction-assisted drainage.

A 16-gauge Tuohy needle was used to introduce an 18-gauge epidural catheter (both by SIMS Portex Ltd, Hythe, UK) into the bladder suprapubically following distension with irrigating fluid. Its position was checked endoscopically. The catheter was then attached to the transducer and invasive pressure system of a standard anaesthesia monitor (AS/3, Datex Ohmeda, Hatfield, UK) and used to measure intra-operative bladder pressure relative to the midaxillary line.

Absorption was indicated by the presence of ethanol in the expired breath according to the method developed by Hulten *et al.* [8] and Hahn [9]. Breath samples were taken every 10 min and ethanol detected by hand-held analyser (Alcolmeter S-D2, Lion Laboratories). Patients were classified as 'absorbers' if ethanol was detected in the breath at any time intra-operatively or immediately postoperatively; no attempt was made to quantify absorption. Because of the known high likelihood of ongoing irrigant absorption once absorption has begun [3], active attempts were made to lower vesical pressure and to reduce absorption once any expired ethanol was detected. Pressure data subsequent to these interventions were not included in our analysis.

Intravesical pressure was measured every 1 min. For each 10-min period between breath samples, a mean pressure was recorded, and peak pressure was taken to be the highest pressure over any 1 min of the 10. The area under the vesical pressure−time curve prior to absorption for each patient was calculated (mean pressure × time) and compared between groups as a means of investigating the significance of cumulative exposure to a given pressure.

Other data recorded for each patient included the experience of the operator, patient age, the mass of recovered prostate resectate in grams, the histological diagnosis of the resected tissue, operating time in minutes and the presence of symptoms of the irrigant absorption syndrome. Tests of significance were by Student's *t*-test unless stated otherwise.

Table 1 Resection characteristics.

	Patient age; years	Resection duration; min	Resectate mass; g
Absorbers	72.3	38.6 (15.6)	15.2 (11.9)
Non-Absorbers	75.3	23.4 (9.3)	16.8 (15.6)
Significance	Not significant	p = 0.002	Not significant

All values are expressed as means (SD). 'Resection duration' refers to the entire operating time in both groups, including operating time after ethanol excretion was detected in the absorbing group. Significance testing by Student's *t*-test.

Results

Thirty-five ASA I or II patients from the elective surgery waiting list were studied. There were two incidents of inadvertent catheter transection by the resectoscope and in both cases the fragments were retrieved endoscopically.

On the basis of expired breath ethanol, nine (26%) of our patients had absorbed irrigating fluid 20 min into their surgery and all 15 (43%) who went on to absorb did so by 40 min. Overall operation times were significantly longer in the group of patients proven to have absorbed than in the non-absorbing group (Table 1). Histological diagnosis of prostate carcinoma was made in only one of the absorbing patients and two of the non-absorbers, all others were given a diagnosis of benign prostatic hyperplasia. Age and mass of prostate tissue resected did not differ between groups (Table 1). No patients were symptomatic for glycine solution absorption and no patients were found to be hyponatraemic.

Mean and peak intravesical pressures were higher in those patients who absorbed than in those who did

Table 2 Pressure variables.

	Mean pressure (mmHg)	Peak pressure (mmHg)	Pressure−time product (mmHg.min)
Absorbers	19.1 (7.7)	33.8 (10.5)	458 (237)
Non-absorbers	12.4 (6.5)	25.5 (12.1)	306 (183)
Significance	p = 0.00004	p = 0.0007	p = 0.026

All values are expressed as means (SD). Pressure−time product refers to the area under the pre-absorption pressure−time curves in both groups, excluding the time after ethanol detection in the group of absorbers. Significance testing by Student's *t*-test.

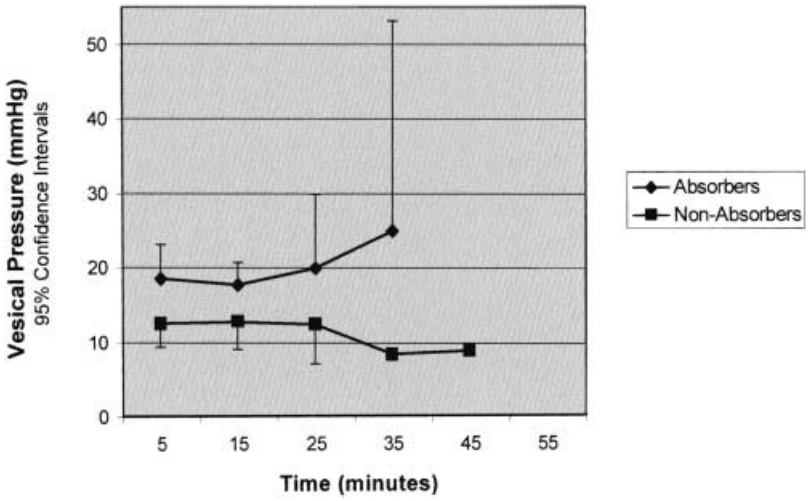

Figure 1 Mean vesical pressure vs. time. For the sake of clarity, confidence intervals are omitted once fewer than three patients remain.

not (Table 2). Analysis of peak and mean pressure by time (Figs 1 and 2) reveals consistently higher pressure among the absorbing patients from the outset. Furthermore, the mean (SD) final peak pressure measurement *during* ethanol excretion in the absorbing group was 36.3 (9.2) mmHg; significantly higher than all other peak pressures recorded during resection in both groups (27.5 (12.1) mmHg; $p = 0.002$).

The pre-absorption pressure-time product among the absorbing patients was significantly higher than among the non-absorbers (Table 2). Associations between pressure-time product and traditionally stated risk factors for each patient were then sought. Comparison of prostatic resectate weight and the pressure-time product for each patient using Kendall's method [11] revealed a significant association (rank correlation coefficient = 0.294; $0.046 > p > 0.01$). Pressure−time product was also significantly higher in the resections performed by trainees than in those performed by consultant-grade staff (Table 3).

Discussion

This study demonstrates a novel technique for vesical pressure measurement using a cheap, convenient and readily available catheter. Our experience of transected catheters serves to emphasise the importance of checking for the tip marker after removal. In contrast to purpose built devices [6], the equipment used in this study is available on all modern anaesthetic machines. While it could be argued that the dynamic characteristics of our system have not been tested *in vitro*, differences between catheter systems are known to affect the shape of pressure waveforms without affecting the calculated mean.

Our system is not part of the irrigation line and involves no flow. Unlike the pressure measurement systems of Hubert *et al.* [7], it is a direct measurement and does not therefore require calibration. It also provides a continuous variable for operator feedback, which our resectionists-in-training have found particularly useful in

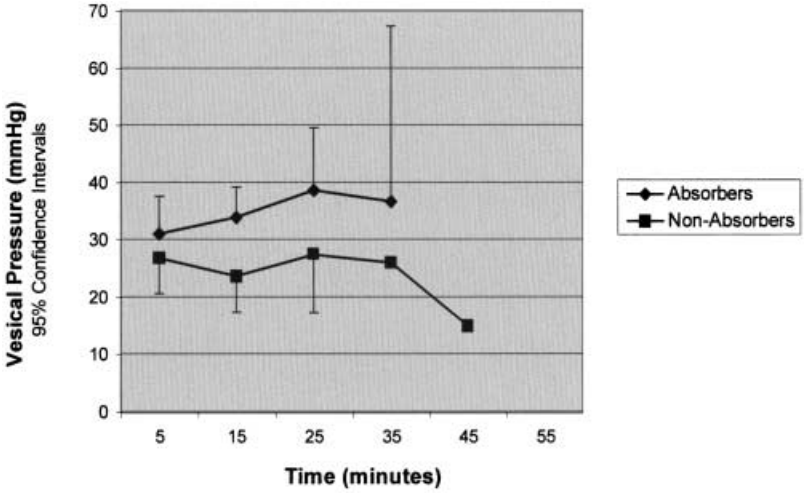

Figure 2 Peak vesical pressures vs. time. Data points represent 'means of peak pressures' rather than the overall peak. Confidence intervals are omitted once fewer than three patients remain.

Table 3 Operator experience.

	Duration (min)	Resectate mass (g)	Pressure–time product (mmHg.min)
Trainee surgeon	37.2 (16.0)	15.0 (12.5)	441 (267)
Consultant surgeon	23.1 (8.4)	14.3 (15.8)	253 (183)
Significance	$p = 0.002$	Not significant	$p = 0.02$

All values are expressed as means (SD). Duration refers to the surgical time in all cases. The pressure–time product refers to the area under the pre-absorption pressure–time curves in both groups, excluding the time after ethanol detection in the group of absorbers. Significance testing by Student's *t*-test.

managing bladder irrigation. Unlike the use of ethanol as a marker for absorption [12], pressure surveillance removes reliance on patient technique.

Our results confirm the association between vesical pressure during irrigation for TURP and absorption of irrigation fluid. The incidence of detectable absorption in our sample agrees roughly with the findings of earlier investigators [3, 4, 6]. Assuming iso-osmolarity, any flux between body compartments is dependant on pressure differential and impedance to flow. In the case of vascular absorption through open prostatic sinuses, impedance depends on gland vascularity and surgical haemostasis, while pressure differential is the excess of prostatic bed pressure over pelvic venous plexus pressure. In contrast, extravascular irrigant absorption depends on prostatic bed pressure with impedance reflecting the state of the prostatic capsule.

We feel that exposure of the prostatic bed and bladder mucosa to excessive irrigant pressure over time is the only modifiable risk factor for absorption, explaining as a 'final common pathway' the other well-known modifiable risk factors.

The time components to the graphs of our absorbing group are much shorter than those of the non-absorbers because pressure data subsequent to ethanol excretion were excluded from the analysis. Despite this, the pressure–time product remains higher among absorbers and is a reasonable predictor of ethanol excretion. If the duration of resection is important as a risk for irrigant absorption, it is probably only because the cumulative effect of a given pressure is more important.

Our analysis showed a correlation between pressure-time product and both resectate mass and the experience of the resectionist. Whereas a large gland may have large venous sinuses that bleed freely, a skilled operator will deal with these quickly at low bladder pressure, maximising the impedance to absorption while minimising pressure exposure. Thus, operator inexperience is a risk because of prolonged resection time, inadequate haemostasis and pressure exposure. Conversely, an inexperienced operator who works with irrigation at low pressures, and pays attention to haemostasis, can reasonably expect to have a low risk of absorption.

We sought to define the pressure pattern most likely to result in absorption. More important to daily practice are the characteristics of a 'safe' pressure pattern which is likely to prevent absorption. The differences in pressure variables between groups in our study were most significant early in the resections, probably reflecting the dwindling data from absorbing patients as they were progressively excluded from the analysis. Alternatively, it is possible that the early phase of difficult transurethral resections is inherently associated with open venous sinuses and high bladder pressures, with operators using this time to optimise their irrigation and diathermy technique for individual resections. The highest peak pressures were found *during* ethanol excretion by the group of absorbers. While high peak pressures do contribute to high mean pressures, this temporal relationship suggests a 'triggering pressure' for absorption on the apparent background of high mean pressure. Perhaps the bladders of patients who go on to absorb are remarkable for low compliance and poor response to irrigation manoeuvres.

In none of the pressure variables studied could we detect a discrete 'threshold' value whose sensitivity and specificity are adequate for unqualified use as a predictor of irrigant absorption, suggesting that there is a continuum of risk with higher pressures carrying more predictive weight than lesser values. Nevertheless, the 60% of patients in our sample whose mean vesical pressure was kept below 15 mmHg and whose peaks did not exceed 30 mmHg were 'non-absorbers' with a predictive value of 85%. Inherent in these levels is a clinical safety margin, because the smallest absorption detectable by our system is ≈ 320 ml. Symptomatic absorptions are of the order of 1500 ml [9], so if mean and peak pressures are kept below these limits, clinically significant absorption should be avoided.

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FORUM

The use of central venous cannulae in neuroanaesthesia

A survey of current practice in the UK

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Summary

A postal questionnaire was sent to all UK consultant members of the Neuroanaesthesia Society to ascertain whether there was any consensus on indications for use and route of insertion of central venous cannulae in elective neuroanaesthetic practice. Five brief clinical scenarios were presented. Of 179 respondents, 98% indicated that they would insert a central venous cannula into patients requiring excision of an acoustic neuroma in the sitting position, 76% for clipping of an intracranial aneurysm and 75% for resection of an arteriovenous malformation. The antecubital fossa was the preferred route of insertion for 43.5% of respondents with 36.5% preferring the internal jugular approach. The subclavian (17%) and femoral (3%) routes were unpopular first-choice approaches. A significant proportion of respondents (43.5%) do not routinely order a chest X-ray at any stage following pre-operative central venous cannulation. The indications for use and advantages and disadvantages of each route of insertion, with reference to neuroanaesthetic practice, are discussed.

Keywords *Catheterisation*: central venous. *Anaesthesia*, *techniques*: general. *Surgery*: brain.

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Central venous cannulae are widely used in neuroanaesthetic practice although their use may, on occasions, be associated with serious complications. Such complications include inadvertent arterial puncture, pneumothorax and haemopneumothorax [1, 2]. The risk of such complications occurring depends to a great extent upon the route of insertion chosen. The internal jugular and subclavian routes present considerably greater risk than the antecubital fossa approach, particularly in neurosurgical patients, although there may be advantages in using the former routes. In view of this, we set out to determine whether any consensus exists among neuroanaesthetists in the United Kingdom (UK) as to the indications for elective central venous cannulation, preferred route of insertion and the need for chest X-ray following insertion, in adult neurosurgical patients.

Methods

A questionnaire (Appendix) was sent to 214 UK consultant anaesthetists identified as having regular neuroanaesthetic sessions (via the Neuroanaesthesia Society local co-ordinators). Five clinical scenarios were presented and respondents were asked to state, for each, whether they would normally insert a central venous cannula and, if so, whether it would be primarily for intra-operative use, postoperative use or both. They were also asked about their routine practice regarding the ordering of a chest X-ray, their preferred route(s) of insertion, the length of time since their appointment as consultant and their number of sessions in neuroanaesthesia per week.

Results

One hundred and seventy-nine completed replies were received (84% response rate). Table 1 details the respondents' views on the need for insertion of a central venous cannulae in the five clinical scenarios presented and Table 2 shows the principal intended period of use.

Table 3 summarises respondents' preferred route of insertion. Many respondents, however, indicated that the femoral route would be their first choice in paediatric practice – this has not been included in the table as the audit was restricted to adult practice. Table 4 details the back-up approach used when the preferred route of central venous access is either unsuccessful or unavailable. The very even distribution shows that the subclavian and femoral routes were much more popular as back-up routes than as first-choice routes.

Of the respondents, 39% indicated that they are only prepared to consider one approach for central venous cannulation; the approach used by this subgroup showed a similar distribution to the preferred approach of those prepared to use two or more routes. Eight per cent of respondents were prepared to consider all four approaches. Interestingly, two respondents indicated that they would not insert a central venous catheter in any of the outlined

Table 1 Percentage of respondents who would insert a central line for each scenario ($n = 179$).

Scenario		
1	Sitting acoustic neuroma	98*
2	Clipping of intracranial aneurysm	76
3	Supratentorial arteriovenous malformation	75
4	Frontal glioma, elderly, ASA III	53
5	Parkbench acoustic neuroma	52

ASA – American Society of Anesthesiologists grading. *10% of respondents indicated they would not do this case in sitting position; the figure of 98% applies to those who would.

Table 2 Principal intended period of use of central line. Percentage of respondents for each scenario ($n = 179$).

Scenario		Intra-operative	Post-operative	Both
1	Sitting acoustic neuroma	46	1	53
2	Aneurysm clipping	14	11	75
3	Arteriovenous malformation	36	1	63
4	Frontal glioma, elderly, ASA III	24	1	75
5	Parkbench acoustic neuroma	45	1	54

Table 3 Preferred route of central line insertion. Percentage of respondents ($n = 179$).

Route	
Antecubital fossa	43.5
Internal jugular	36.5
Subclavian	17
Femoral	3

Table 4 Popularity of four routes of central access as backup when preferred route unsuccessful/unavailable. Percentage of respondents ($n = 179$).

Route	
Antecubital fossa	26
Internal jugular	25
Subclavian	21
Femoral	17

Table 5 Routine practice regarding the ordering of a chest X-ray following central line insertion as part of a neuroanaesthetic. Percentage of respondents ($n = 177$)

Where/if chest X-ray ordered	
In recovery area or HDU/ICU at the end of the case	47.5
None ordered unless specifically indicated, e.g. difficulty threading guidewire	43.5
Depends	5.5*
In anaesthetic room or theatre prior to starting case	3.5

HDU – High Dependency Unit; ICU – Intensive Care Unit. *Of this number, half would not order an X-ray unless the line was to be left in postoperatively; the other half normally use the antecubital fossa route and do not order an X-ray, but would order an X-ray for internal jugular or subclavian routes.

Table 6 Preferred route of access for those who do not routinely order a chest X-ray following central line insertion. Percentage of respondents ($n = 76$).

Route	
Antecubital fossa	47
Internal jugular	35
Subclavian	14
Femoral	4

scenarios whilst 65 (41%) would want central venous access in all five scenarios. The antecubital fossa was the preferred route of insertion (58%) among this latter group with other approaches less popular (internal jugular, 28%; subclavian, 13%; femoral, none). Comparison of these results with Table 3 suggests an association between those who insert central venous cannulae most frequently and use of the antecubital fossa approach.

Table 5 summarises respondents' views on the need to seek X-ray confirmation following insertion of a central venous cannula, and when this would occur. Table 6 details the preferred route of insertion used by those practitioners who do not seek routine X-ray confirmation, and shows it to be almost identical to that of the respondents as a whole (Table 3).

Finally, respondents were asked to indicate the number of years since consultant appointment and the number of neuroanaesthesia sessions per week. Sixty-one per cent have been appointed less than 10 years, 26% between 10 and 20 years, and 13% over 20 years. The number of sessions varied from one (4%) to eight (1%), with 82% working between two and four sessions per week. There was no significant relation between seniority, number of dedicated neuro-anaesthesia sessions and preferred route of insertion.

Discussion

It is interesting to note that consensus on the need for central venous cannulation was limited to three of the scenarios presented. The specific indications for insertion in each scenario were not ascertained from individual respondents. Nevertheless, we believe the main indications are as follows: the sitting acoustic neuroma – aspiration of venous air embolism; the clipping of an intracranial aneurysm – a route for central venous pressure (CVP) measurement and peri-operative fluid and drug administration; the resection of arteriovenous malformation – peri-operative fluid management. The above represents our considered opinion which, if accepted, indicates almost unanimous support for the presence of a central venous cannulae in any patient where venous air embolism is anticipated. This is hardly surprising given conventional teaching, although it is interesting that the majority of practitioners do not consider it necessary to obtain X-ray confirmation of correct placement pre-operatively. If the indication for central cannulation includes the possibility of aspiration of venous air emboli, it is clearly vital to have the catheter tip in or near the right atrium [3]. We suggest pre-operative X-ray confirmation of correct placement in this situation, although it must be remembered that the position of the tip may move during final pre-operative positioning.

We were surprised to find that 43.5% of respondents did not routinely order a chest X-ray pre- or postoperatively following central venous cannula insertion. This appears to be a departure from recommended practice [4]. It is possible that routine chest X-ray is arranged once the patient returns to the ward and that the anaesthetist does not consider this part of their responsibility, although we attempted to exclude this by the wording of the questionnaire. A recent study involving 107 internal jugular catheter placements showed that, of 61 predicted to be free of complications or malpositions by clinical criteria, there were nine (14%) unexpected malpositions shown on chest X-ray. The authors' conclusion was that clinical factors alone will not reliably identify malpositioned catheters and that chest X-ray is necessary to ensure correct position [5].

Correct catheter tip placement was the subject of a recent editorial [6]. If the tip lies within the heart there is a risk of myocardial perforation leading to cardiac tamponade which, although rare, carries a very high mortality. A convenient way of avoiding this complication has been recently described, whereby the catheter tip should be positioned above the carina on chest X-ray, which places it above the reflection of the pericardium onto the superior vena cava [7]. For left-sided catheters it is safer to withdraw the tip further still, to the mid-point of the inominate vein, to avoid erosion of the lateral wall of the superior vena cava [6]. A catheter tip placed

deliberately in the right atrium for aspiration of air should be withdrawn once the risk of air embolism has passed.

Interestingly, a quarter of respondents did not consider central venous access necessary in patients undergoing clipping of an intracranial aneurysm. Postoperative vasospasm may ensue in such patients, requiring treatment by manipulation of the cardiovascular system using intravenous drugs and fluids, known as 'triple-H' therapy (hypervolaemia, haemodilution and hypertension) [8]. A multilumen central venous cannula is required to ensure this is undertaken safely and effectively. There are two possible explanations for the decision not to use such a cannula by a quarter of respondents; they work in institutions where intensive care is not routinely available for the postoperative care of such patients and/or the clinicians involved are unconvinced by the benefits of such therapy. We suggest that it is safer to place a central venous cannula in an anaesthetised patient pre-operatively than in a cerebrally compromised postoperative patient.

The decision to insert a central venous cannula, as well as the approach used, will depend upon the clinical indications for its placement balanced against the potential complications associated with the particular route of insertion. Each approach has advantages and disadvantages which must be considered.

The antecubital fossa route has the great advantage of no reported major complications arising from venepuncture and, further, does not require the patient to be placed head-down during cannulation. Successful central venous placement using this route is reported by most studies to vary between 65% and 75% [9]. An apparently acceptable CVP trace does not confirm central placement [10]. The length of the catheter is not ideal for the rapid withdrawal of large volumes of air. The maximum number of lumens available is two; this and the large dead space makes it unsuitable for multiple drug therapy postoperatively. Finally, if the cannula is left *in situ* for a prolonged period of time ($>$ 24 h), there is a high incidence of thrombophlebitis in the arm [9]. Thus, this route is best suited to intra- and immediate postoperative CVP measurement.

The right internal jugular route has a high success rate for experienced clinicians [11] and appears to be the route most likely (94–100%) to ensure correct cannula tip placement at or above the right atrium [12]. An important advantage over the subclavian route is that the risk of pneumothorax is low in experienced hands, and should theoretically be avoidable by using a high approach [2, 12]. A multilumen cannula will facilitate multiple intravenous drug therapy for several days postoperatively. The disadvantages of this route include the risk of serious complications [12]; most of these are rare but deaths are still reported [13, 14]. The commonest complication of the internal jugular approach is carotid puncture, the incidence of which varies from 0.75% [11] to 10% [2] in adult practice. Although the risk decreases with practitioner experience, it is never eliminated and is a particular hazard as the pressure needed for haemostsis will almost inevitably lead to reduced cerebral perfusion pressure. The head-down tilt traditionally used during insertion is also a disadvantage in neurosurgical patients. The anatomy of the internal jugular vein has been found to be sufficiently abnormal to complicate access in 8.5% of hospital patients requiring central venous cannulation [15]. There is an exponential increase in complications with successive attempts [1, 2] and we suggest that after three attempts an alternative route be used. A meta-analysis has shown that the use of real-time ultrasound guidance reduces the risk of complications significantly [16], particularly when access is predicted to be difficult [16, 17]. A recent editorial makes a strong case for the introduction of ultrasound guidance as routine practice before and during central venous cannulation [18].

The subclavian route is probably the most suitable for long-term postoperative use, with the skin entry site being easiest to keep clean, and the cannula securely fixed. Correct tip placement is reported to be between 85 and 95% [1, 4, 19, 20]. The left subclavian vein curves more gently towards the superior vena cava making successful central placement more likely from this side – this is our own experience and is confirmed by some studies [4, 21], although others report no difference [2, 20]. As with the internal jugular route, the time spent with head-down tilt for placement should be kept to a minimum. The subclavian route is suitable for intra-operative and postoperative use once safely inserted but the risk of serious complications on insertion, notably pneumothorax (up to 12.4% in one study [22]), is higher than for any other route [12]. The emergency management of such complications may be difficult if their presence is not detected until surgery has commenced.

The femoral route has the advantage of relatively easy and uncomplicated insertion [23], although damage to large vessels resulting in local [24] or retroperitoneal [25] haematoma can occur. Along with the antecubital fossa approach, this route has the added advantage of avoiding head-down positioning during insertion. In a study of 395 patients, the incidence of infective complications was no higher for femoral (3.7%) than non-femoral (7.3%) central venous catheters [26]. The main disadvantage of this route is that catheter tip placement is uncertain, with successful central venous placement rates of only 60–75% [20] making CVP measurement unreliable. Furthermore, the misplaced catheters have been found to enter the ascending lumbar vein, internal iliac vein, left renal vein and the contralateral iliac vein, giving rise to potential toxicity from venous perfusion if inotropes are used. Finally, deep vein thrombosis has been demonstrated following 25% of femoral vein catheterisations [27].

In our opinion, the antecubital fossa route may be ideal for CVP measurement in the immediate peri-operative period. Beyond this indication, the internal jugular route offers the best compromise for routine neuro-anaesthetic practice, being well suited to CVP measurement, air aspiration and peri-operative drug infusions and fluid manipulation. When sited with care by experienced practitioners, after careful consideration of the risk/benefit ratio in any particular patient, it has a low and, in our opinion, acceptable complication rate. The availability of ultrasound assistance as a routine would undoubtedly reduce this complication rate further.

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Table 7 Appendix.

Details of questionnaire, as sent out to all neuro-anaesthetists in the UK. AVM – Arteriovenous malformation: NIDDM – non-insulin dependent diabetes mellitus: HDU – High Dependency Unit: ICU – Intensive Care Unit.
Please indicate whether or not you would normally insert a central line in the following cases – if *yes* please state if principally for intra-op use/post-op. use or both:

	Yes	**No**
(Intra-op/Post-op) or Both		
1. Excision of an acoustic neuroma in a previously well 40-year-old, in the sitting position.	☐	☐
2. Clipping of a middle cerebral artery aneurysm in a previously well 24-year-old, 72 h after subarachnoid haemorrhage and now grade one.	☐	☐
3. Excision of a supratentorial AVM in an otherwise fit 30 year old.	☐	☐
4. Excision of a frontal glioma in a 70-year-old with NIDDM, hypertension and stable angina.	☐	☐
5. Excision of a small, discrete, acoustic neuroma in a previously well 40-year-old, in the parkbench position.	☐	☐

Following insertion of a central line for a theatre case, which of the following describes your routine practice regarding the ordering of a *chest X-ray?*

In anaesthetic room/theatre prior to starting the case.	☐
In recovery area, HDU or ICU at the end of the case.	☐
No X-ray unless there is a specific reason, e.g. difficulty in threading guidewire.	☐
Other – please specify.	☐

Which route(s) do you routinely use? If more than one, please indicate your order of preference if you have one (1 = favoured route) and mark "N" for those you do not normally use.

Subclavian ☐	Antecubital fossa ☐
Femoral ☐	Internal jugular ☐

Is the route and/or the side you select, influenced by the nature/side of the surgery? If you have any reasons for/against any particular route, either in general or as dictated by a specific procedure, please detail below.

How many neurosurgical sessions do you have in your job plan?	☐
How long have you been a consultant?	< 10 years/10–20 years/ > 20 years

FORUM

Quantitative assessment of motor block in labouring women receiving epidural analgesia

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Summary

The assessment of motor block associated with epidural analgesia is traditionally performed using the modified Bromage Score. However, it is a qualitative and quantitative measurement of both spread and intensity of motor block in the lower limbs, and it has been adapted from Bromage's original use as an assessment of the adequacy of epidural anaesthesia for abdominal surgery. A number of quantitative assessment methods exist but these are either laboratory based and/or impracticable in the clinical situation of labour. We therefore set out to devise a quantitative assessment method which would be easy to use and acceptable to labouring women receiving epidural analgesia. A force transducer was modified to enable power of hip adduction to be assessed quantitatively before and after epidural analgesia was established. These results were compared with the modified Bromage Scale and an extended scale which further subdivided the scores between 0 and 1. Our results show that there is a large variation in the quantitative measurement of motor block (as measured by adductor strength) that may not be detected by the sole use of the modified Bromage Score. We suggest that future studies to assess motor block in the clinical setting use an additional quantitative method of assessment.

Keywords *Anaesthesia, regional*: epidural. *Obstetrics*: labour. *Neural block*: motor.

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Epidural analgesia is well established as a means of providing pain relief during labour. However, in achieving this there may be a price to pay in terms of motor block during labour and expulsive effort in the second stage. Preservation of muscle power is important as it enables the labouring woman to be mobile in bed, maintains a greater sense of control and reduces her dependency on attending midwifery staff. Strategies to reduce motor blockade include using lower concentrations of local anaesthetics with the addition of opioids [1], or by using newer local anaesthetic agents, e.g. ropivacaine [2].

The degree of motor block associated with epidural analgesia has classically been assessed using the modified Bromage Score [3].

Grade 0 No motor block

Grade 1 Inability to raise extended leg, able to move knees and feet

Grade 2 Inability to raise extended leg and move knee, able to move feet

Grade 3 Complete motor block of the lower limbs.

There are, however, a number of limitations with this scoring system. It is a qualitative assessment of motor block and does not have the required sensitivity to detect lesser degrees of motor weakness associated with the segmental block required for analgesia in labour [4]. It assesses motor function in different muscle groups with different nerve root innervation, making it a measure of spread as well as density of block. Bromage originally devised it to assess the adequacy of epidural anaesthesia for abdominal surgery but it was subsequently adapted for use in labouring women receiving epidural analgesia.

The use of low-dose local anaesthetic solutions has reduced the degree of motor block to the extent that one study, using 0.1% ropivacaine, showed no motor block (Grade 0) according to the modified Bromage Score [5]. However, a further study, using a quantitative measure of muscle function (hip flexion, knee extension and plantar flexion of the big toe), showed that, by the time muscle function had reduced to Grade 1 on the modified Bromage Score, $\approx 60\%$ of muscle power (measured by knee extension) had been lost [6].

In order to measure motor block with increased sensitivity it is necessary to be able to measure changes in muscle function between Grade 0 and Grade 1 of the modified Bromage Score. A number of methods have already been used to provide a quantitative assessment of motor block following epidural analgesia. Studies using average rectified electromyography (ARMEG) of the abdominal muscles and measurements of isometric muscle function during hip flexion, knee extension and plantar flexion of the big toe have been performed on volunteers receiving epidural analgesia [5, 7]. These studies, however, were performed on male volunteers and used methods that would be impractical in the clinical setting of a labour suite.

We therefore set out to devise a simple, quantitative method of measuring motor block in labouring women receiving epidural analgesia and to assess the adequacy of the modified Bromage Score.

Methods

The study was approved by the local ethics committee and all participating women were recruited before the onset of painful labour and after providing informed written consent.

The muscle group selected for measurement was the hip adductors. Hip adduction is an easily performed and repeatable action that does not require a labouring woman to leave her bed, assume awkward positions or be strapped into cumbersome and restrictive measuring devices. The hip adductors are supplied by the second to fourth lumbar nerve roots, which have previously been shown to be those most affected by epidural analgesia (measured by knee extension) administered at the level of the second or third lumbar interspace [6].

Measurement of motor block was performed using the following methods.

An extended modified Bromage Score

In view of the limitations of the modified Bromage Score it has become routine practice in our labour suite to subdivide motor block within the Grade 0 to Grade 1 range.

Grade 0 No motor block.

Grade 0+ Able to straight leg raise but slight weakness.

Grade 0++ Able to straight leg raise but significant weakness.

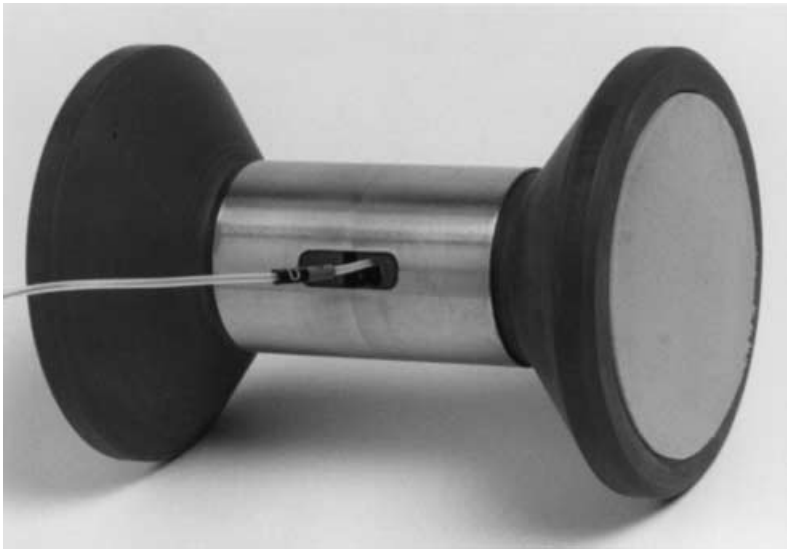

Figure 1 Force transducer in its assembled form.

Grade 1 Inability to raise extended leg, able to move knees and feet.

Grade 2 Inability to raise extended leg and move knee, able to move feet.

Grade 3 Complete motor block of the lower limbs.

Assessment was undertaken for each leg and the worst score used in subsequent analysis.

A purpose-built, battery-powered, electronic measuring device was used, comprising a button load cell (model DC302, Graham and White Instruments Ltd, St Albans, UK) housed in a dumbbell-shaped casing, and an amplifier system. The button load cell has a full-scale range of 30 kg and a typical sensitivity of 2 mV per excitation at full scale. The amplifier was based on a conventional system described previously by Black & Amoore [8]. It was powered by a regulated $\pm$ 5 V supply driven from a 9 V PP3 battery. The gain of the amplifier can be adjusted to give an output of 1 V.10 kg^{-1}. Figure 1 shows the force transducer in its assembled form and Fig. 2 shows it in its component parts.

The study was performed in the labour suite of a large maternity unit (6500 deliveries per annum) with an epidural rate of 26%. Women were recruited prior to a formal request for epidural analgesia if they had indicated to the attending midwifery staff that epidural analgesia was part of their birth plan. This allowed the recruiting process to be carried out during a relatively pain free time of their labour. Each woman was given an information sheet and written informed consent was obtained. The baseline measurements were taken on formal request for epidural analgesia before epidural blockade was performed. No one was recruited if they, their partner, their

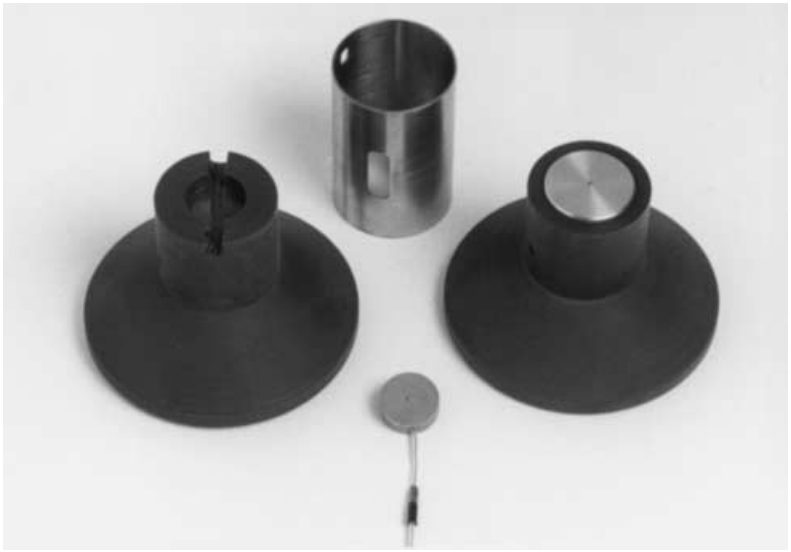

Figure 2 Force transducer in its component parts.

attending midwife or we considered them to be too uncomfortable to give valid consent.

Assessment was undertaken with the woman sitting in her bed reclined to an angle of between 40° and 50° from the horizontal and having her legs lying straight in a neutral position (neither internally nor externally rotated). Arterial blood pressure was measured and care was taken to avoid supine hypotension. The mothers were not tilted laterally during the short period of measurement, provided there were no symptoms or signs of supine hypotension. This avoided rotational movement of the hips. A set of baseline readings was taken between contractions prior to insertion of the epidural.

Each set of readings comprised an extended modified Bromage Score and measurements with the force transducer. Measurement with the force transducer was obtained by placing it between the medial epicondyles of the woman's knees and asking the woman to squeeze her knees together while keeping her legs straight. The woman was asked to perform three to five gentle squeezes in order for her to become accustomed to the technique. They were then asked to maximally squeeze the device between their knees and hold for 3 s. This was repeated three to five times and the final reading was taken as the highest consistent reading on two attempts.

After securing intravenous access, the epidural catheter was sited with the woman in either the sitting or lateral position according to the preference of the anaesthetist. All epidural catheters were sited at the second or third lumbar interspace using a loss of resistance technique with a 16 G Tuohy needle. The epidural catheter (lateral-eyed) was positioned to leave 3–4 cm in the epidural space and a test dose of 4 ml of lidocaine 2% administered. The block was established using either 8 ml of bupivacaine 0.25% or 15 ml of bupivacaine 0.1% with 30 μg of fentanyl according to the clinical decision of the anaesthetist. A subsequent set of readings was taken 30–40 min after epidural block was established. Epidural analgesia was maintained using intermittent top-ups of 8 ml of bupivacaine 0.25% or 15 ml of bupivacaine 0.1% with 30 μg of fentanyl. Further readings were taken before and 30–40 min after each subsequent top-up. All results were converted to a percentage of the pre-epidural baseline readings.

Statistical analysis was performed using the correlation coefficient to compare both the extended and the original Bromage Scores with the transducer readings. The degree of agreement between the extended and original modified Bromage Scores was calculated using the Kappa statistic.

Results

Seventeen women were recruited initially, however, six withdrew or were withdrawn following baseline measurements. Reasons for withdrawal included fetal distress requiring operative delivery and the onset of second stage of labour prior to the first set of postepidural measurements. We therefore obtained results for 11 women, nine of whom were primiparous and two multiparous (Table 1), giving a total of 40 sets of measurements. The measurements using the transducer were plotted against the worst modified Bromage Score (Fig. 3). This showed a large variation in the quantitative measurement within each of the extended modified Bromage Scores (Table 2).

Table 1 Population characteristics. Median [range].

Age; years	29 [22–39]
Gestation; weeks	40 [39–42]
Height; cm	163 [155–168]
Weight; kg	64 [52–112]

Table 2 Variation in transducer readings (% of control) within the extended modified Bromage Scores. Median [range].

Extended modified Bromage Score	Transducer readings (% of control)
0	81.5 [68.4–125]
0+	100.4 [68.2–148.1]
0++	95.5 [58.3–133]
1	59.2 [25–116.7]
2	20.8 [8.3–33.3]
3	–

The correlation coefficients for the extended modified Bromage Score and the original modified Bromage Score against the transducer readings were −0.58 and −0.67, respectively. We repeated this with specific reference to the results obtained between Grades 0 and 1, which gave a correlation coefficient of −0.42 and −0.55, respectively. The degree of agreement between the extended modified Bromage Score and the original modified Bromage Score, for all grades, was 0.4. This indicated the strength of agreement between the two methods and could, at best, be described as fair [9].

Discussion

All the women entered into the study found the transducer easy and acceptable to use and found that it helped them to feel more involved in the assessment of their epidural.

From the statistical analysis of the results for both scoring systems it is clear that there is only modest correlation with the transducer readings. Interestingly, the

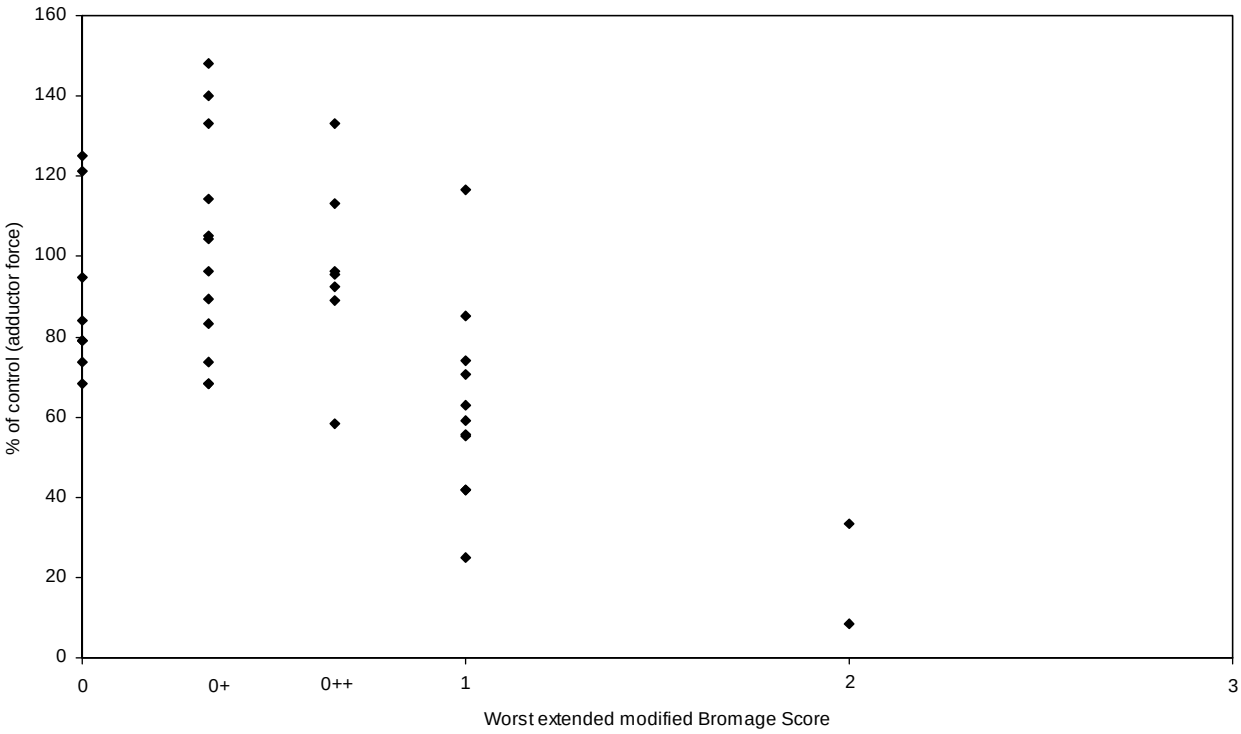

Figure 3 Transducer readings (% of control) at worst extended modified Bromage Score.

modified Bromage Score appears to correlate better than the extended modified Bromage Score. This may be due to the subjective nature of our subdivisions of Grade 0 or it may be due to the modified Bromage Score being so imprecise as to miss the changes in muscle (adductor) strength demonstrated within Grade 0. Breen *et al*. [10], in a study to compare two epidural analgesic regimens on the ability to ambulate, commented that the Bromage Score is a very crude assessment and to this end they devised their own modified version, adding two new categories. These were: (i) detectable hip flexion weakness, and (ii) ability to perform a partial knee bend while standing (if there was no detectable weakness of hip flexion while supine). In their discussion they state that it is important to realise that patients who receive only epidural fentanyl and a test dose (containing local anaesthetic) may have subtle leg weakness. While they suggest that performing a partial knee bend could be used as a criterion for ambulation during labour, we suggest that a quantitative method of measurement may be a better way to detect this subtle weakness prior to attempted ambulation. Which of these two methods would better predict success with regard to ambulation has yet to be determined.

The results in Table 2 show the wide variation in transducer readings within each of the five subdivisions of the extended modified Bromage Score. Even where no motor block was apparent (Grade 0 on the extended modified Bromage Score), the transducer readings revealed a range in adductor strength of 68.4−125% (median 81.5%) of the baseline reading. This demonstrates the inadequacy of the modified Bromage Score (extended or not) to detect otherwise measurable changes in muscle (adductor) strength. This may become increasingly important when assessing motor block in the clinical setting where low dose anaesthetic solutions are used. A range of transducer values, of adductor strength, of 25–116.7% (median 59.2%) corresponding to Grade 1 supports the conclusion of a previous study that the grading of the intensity of motor block by the Bromage Scale is not precise [6].

Figure 3 shows the transducer readings and their corresponding worst extended modified Bromage Scores for all of the women. This demonstrates the wide variation encountered within the subdivisions of the scoring system within Grades 0–1. It could be argued that the variation in muscle strength is due to variation in the effort made in 'squeezing' the measuring device. However, this argument also applies to the use of the modified Bromage Score and any other technique measuring voluntary muscular effort. We tried to overcome this variable by recording the highest consistent reading on two attempts. It was interesting to note that in some cases the women appeared to improve their muscle power

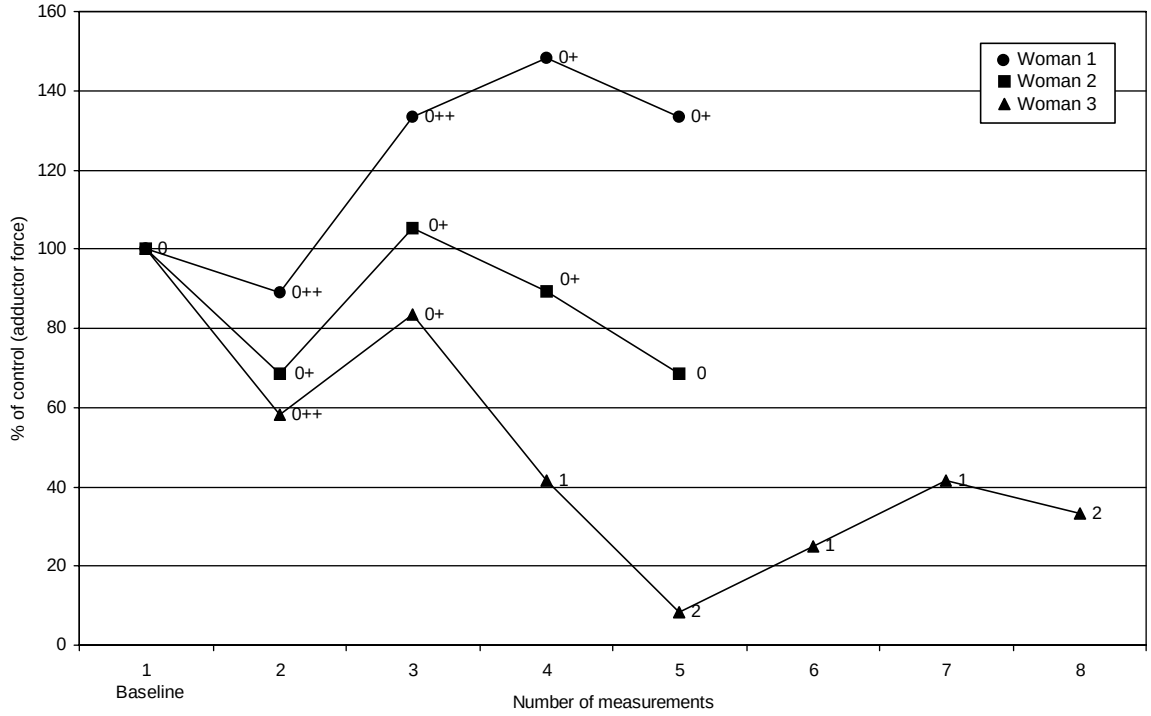

Figure 4 Plot of consecutive transducer readings in three women with corresponding worst extended modified Bromage Scores.

following the establishment of adequate analgesia. The apparent increase in muscle power probably reflects increased muscle power once analgesia has been established, which may reflect the inhibitory effect of pain on voluntary muscle strength.

The apparent increase in muscle power and the disparity between the transducer readings and the extended modified Bromage Score are given in Fig. 4, which shows the consecutive transducer readings for three women with the corresponding worst extended modified Bromage Scores for each reading. The first woman had an apparent increase of strength to 148.1% once analgesia was established. The second woman demonstrated a wide variation (68.4–105.3%) in muscle power while her extended modified Bromage Score remained constant. The third woman showed major disparity between the extended modified Bromage Score and the transducer readings.

Adductor strength is not assessed using the modified Bromage Scale but both the hip adductor muscles (L_{2-4}) and the hip flexors (L_{1-3}), used in straight-leg raising, are innervated by the first to fourth lumbar nerves. The simultaneous measurement of strength in both adductors was considered to be a distinct advantage in the clinical setting because it is easy for women to understand and is simple to perform. It is possible to exert pressure between the knees by internal rotation and care must be taken to ensure the patellae remain in the same horizontal plane to avoid compensating for adductor weakness by hip rotation.

We therefore suggest that the modified Bromage Score is inadequate as the sole measure of motor block in labouring women receiving epidural analgesia, especially if low-dose local anaesthetic regimens are being used. Accurate quantitative assessment of motor block requires a calibrated electronic measuring device, such as the force transducer described. The degree of block (as measured by adductor strength) is easily assessed using this simple device which is acceptable to women in labour. We further suggest that future studies that assess motor block following the establishing of epidural analgesia should use a quantitative measurement method such as we have described in addition to the modified Bromage Score.

Acknowledgments

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FORUM
Sevoflurane inhalation conscious sedation for children having dental treatment

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Summary

An audit at the Queensway Anxiety Management Clinic of 2014 children, referred for dental treatment, showed that relative analgesia by inhalation of nitrous oxide and oxygen failed in 40% of cases successfully to complete treatment. We therefore investigated the efficacy of a new inhalation conscious sedation technique, which reduced the need for general anaesthesia. Seventy-five children aged 3–15 years were given inhalation conscious sedation, with sevoflurane 0.1–0.3% and nitrous oxide 40% in oxygen. In 69 children (92%), the dental treatment was completed successfully. Most children (93%) had recovered fully within 10 min without side-effects. Treatment was fully accepted by 88% of children and 91% of their parents. The use of sevoflurane in low concentrations to supplement nitrous oxide and oxygen for conscious sedation in children appears to be safe and effective and further study is currently in progress.

Keywords *Surgery*: dental. *Anaesthetic, volatile*: sevoflurane. *Sedation*.

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There is consensus among policy makers and professionals that the use of dental general anaesthesia should be minimised [1–5]. The use of conscious sedation in primary dental care contributes to this outcome. Reducing the need for general anaesthesia, particularly for children, is consistent with public expectations and professional concerns [6–8]. A recent review of general anaesthesia and conscious sedation in the UK recommended a 'hospital setting' for dental general anaesthesia from the beginning of 2002 [5]. Our options for preventing anxiety in children having dental treatment will therefore be limited to local anaesthesia combined with either relative analgesia or intravenous conscious sedation. Relative analgesia is an inhalation sedation technique which consists of three elements. Firstly, the administration of low to moderate concentrations from 0% to a maximum of 70% of nitrous oxide in oxygen to patients who remain conscious, with the precise concentration of nitrous oxide fully titrated to the needs of each patient. Second, as nitrous oxide begins to exert its pharmacological effects, the patient is subjected to a steady flow of reassuring and semihypnotic suggestions by the operating dentist. This establishes and maintains a rapport with the patient. Third, the use of fail-safe equipment with a range of safety features; most importantly the equipment should not allow either deliberate or accidental administration of 100% nitrous oxide [9–11].

The Queensway Anxiety Management Clinic was established and supported by Tees Health Authority, with the aim of reducing the use of general anaesthesia in dental practice, by substituting with conscious inhalation and intravenous sedation techniques [12].

An anxiety management protocol was developed and applied to anxious patients referred for dental treatment. Over an 18-month period (January 1998 to June 1999) this resulted in a reduction in general anaesthesia for children from 100 to 25%; this was accompanied by an increase in inhalation conscious sedation (relative analgesia) from 0 to 35% and in intravenous conscious sedation from 0 to 40%. However, an audit showed that in 40% of cases, at an average mixture of 40% nitrous oxide in oxygen, relative analgesia did not allow the successful completion of dental treatment due to poor patient co-operation. Failure of relative analgesia usually required progression to intravenous conscious sedation or general anaesthesia.

Intravenous conscious sedation for children delivered by an anaesthetist usually means giving increasing doses of the benzodiazepine drug, midazolam, or a sedative dose of propofol, or a combination of these drugs with or without an opioid such as fentanyl. Patients must be fully monitored by experienced personnel who are trained to carry out advanced life support. Intravenous conscious sedation can be unpredictable in children. It may precipitate loss of consciousness, a compromised airway, loss of protective reflexes, hypoxaemia and delayed recovery.

We therefore decided to try to improve the results of inhalation conscious sedation, which is safe but not always effective.

Sevoflurane [13, 14] is a well-established and safe anaesthetic agent. It has unique properties of rapid uptake and elimination. For children it is the most widely accepted and tolerated anaesthetic drug. The combination of a fixed ratio of nitrous oxide and oxygen (40/60%) with a variable but subanaesthetic concentration of sevoflurane [15], titrated clinically to allow dental treatment, seemed a natural way to improve the success of inhalation conscious sedation. Concentrations between 0.1 and 0.3% fulfil the criteria for conscious sedation adopted by the General Dental Council [2]:

'A technique in which the use of a drug or drugs produces a state of depression of the central nervous system enabling treatment to be carried out, but during which verbal contact with the patient is maintained throughout the period of sedation. The drugs and techniques used to provide conscious sedation for dental treatment should carry a margin of safety wide enough to render loss of consciousness unlikely.'

Methods

Ethical approval was obtained from the North Tees local research ethics committee and a licence from the Department of Health, Medicines Control Agency.

Seventy-five children aged 3–15 years, ASA I and II, who had been referred to the Queensway Anxiety Management clinic were recruited. Each child's degree of anxiety and need for dental treatment was assessed. Pre-assessment took place a few days before treatment. The standard pre-assessment document including a medical questionnaire was completed by the child's parent or guardian with the help of the dentist [12]. Full verbal and written explanation of the project was provided to parents and written informed consent was obtained. Each child was shown by the dentist how to breathe spontaneously through a nasal hood. The criteria that identified these children as suitable for normal inhalation conscious sedation were applied; these criteria are listed below and account for $\approx 55\%$ of referred children.

1 Children who are anxious aged 3 years and over.

2 Children who speak English as a first language and are not educationally impaired.

3 Children who sit in the dental chair at assessment, are able to tolerate an examination and will accept a nasal hood.

Table 1 The six-point Venham Scale [17].

1. Relaxed: Smiling, able to converse, best possible working conditions. Displays the behaviour desired by the dentist spontaneously, or immediately upon being asked.
2. Uneasy: Concerned. During stressful procedure may protest briefly and quietly to indicate discomfort. Child willing and able to interpret experience as requested. Tense facial expression. Breathing is sometimes held in. Capable of co-operating well with treatment.
3. Tense: Tone of voice, questions and answers reflect anxiety. During stressful procedure, verbal protest, quiet crying, hands tense and raised but not interfering much. Child interprets situation with reasonable accuracy and continues to cope with his or her anxiety. Protest more distracting and troublesome. Child still complies with request to co-operate. Continuity is undisturbed.
4. Reluctant: Tends to reject the treatment situation, difficulty in assessing situational threat. Pronounced verbal protest, crying. Using hands to try to stop the procedure. Protest out of proportion to threat, or is expressed well before the threat. Copes with situation with great reluctance. Treatment proceeds with difficulty.
5. Anxious: Anxiety interferes with ability to assess situation. General crying not related to the treatment. Prominent body movements, needing restraint on occasion. Child can be reached through oral communication, and eventually with reluctance and great effort begins to cope. Protest disrupts procedure.
6. Out of Control: Fails to grasp the reality of the threat, hard loud crying. Screaming, swearing. Unable to listen to oral communication. Regardless of age reverts to primitive flight responses. Actively involved in escape behaviour. Treatment impossible to complete.

4 Children who have non-obstructed nasal airways.

5 Children who do not present with acute oro-facial swellings.

6 Children and parents who are able to give informed consent to treatment with inhalation sedation and who would not be better served with intravenous sedation.

7 Children requiring elective treatment, e.g. orthodontic extractions.

Sedation technique

A mixture of lidocaine and prilocaine (EMLA® cream) was applied to the dorsum of both hands of each child by the parent, 1 h before the appointment, in case venous access was required should the inhalation technique fail.

Parents were invited to be present with their child in the treatment room throughout the dental procedure. Each child lay supine in the dental chair. A pulse oximeter probe was attached and a baseline Eve's test [16] was carried out. Eve's test is a simple control test of spatial awareness in which the child touches the tip of his/her nose with their forefinger with their eyes closed. The anaesthetist then gave a titrated concentration in the range $0.1-0.3\%$ of sevoflurane delivered by a Drager Vapour 2000 vaporiser, in conjunction with 40% nitrous oxide in oxygen at a gas flow of 4–6 $l.min^{-1}$ delivered by a Drager Julian anaesthetic machine. The gases were delivered by continuous flow through an inspiratory limb connected to the nasal hood. From the nasal hood, the expiratory limb incorporating a one-way non-return valve was connected to the scavenging system. The nasal hood was adapted to incorporate a probe to measure fractionated inspired and end-tidal oxygen, nitrous oxide and sevoflurane.

During the procedure, the dentist chatted with the child using hypnotic suggestions and imagery, to reassure the child and distract attention. Before the planned dental treatment, the child was given topical anaesthesia, and 2 min later a local anaesthetic was injected by the dentist. At intervals of 5 min the dentist made a simple assessment of the degree of co-operation using the six-point Venham scale [17] (Table 1). Oxygen saturation, heart rate, fractionated inspired sevoflurane and end-tidal sevoflurane were also measured and recorded every 5 min during the dental treatment.

Recovery

When treatment had been completed, sevoflurane was withdrawn and 100% oxygen was given through a nasal hood for 3 min. The child was then monitored during recovery by a nurse who recorded the following information:

1 the time of the child's arrival in the recovery room;

2 oxygen saturation and heart rate;

3 level of anxiety and co-operation using the six-point Venham scale [17];

4 the child's performance of an Eve's test [16] after 2 and 5 min;

5 when the children had completed the Eve's test they were asked to walk unaided in a straight line across the room under close supervision;

6 visual analogue scale for pain [18] as recorded by the child. (0–1, no hurt; 2–3, tiny hurt; 4–5, little more hurt; 6–7, hurts even more; 8–9, hurts a whole lot; 10, hurts as much as I can imagine);

7 parent's opinion of the overall management of the child (1 = excellent, 2 = good, 3 = satisfactory, 4 = fair, 5 = poor).

8 time to discharge home, when the child was considered to be fully recovered.

The child was then considered to be fully recovered and fit to go home.

Results

The characteristics of the children are shown in Table 2. The technique was effective in 69 of the 75 children (92%).

Table 2 Characteristics of 75 children. Mean (SD) [range].

Age; years ($n = 75$)	6.4 (2.5) [3–15]
ASA classification; I : II	70 : 5
Weight; kg ($n = 75$)	22.4 (8.6) [13–62]
Sedation time; min ($n = 69$)	21.3 (7.9) [10–40]
Discharge time; min ($n = 69$)	7.2 (3.1) [3–15]

During treatment the dentist assessed the level of co-operation using the Venham scale. Sixty-three children (84%) had a score of 1 (relaxed), six (8%) had a score of 2 (uneasy) and six failed to co-operate. Of these, one child scored 4 (reluctant), four (5%) scored 5 (anxious) and one scored 6 (out of control). The mean (SD) sedation time was 21 (8) min [range 10–40].

During treatment the oxygen saturation was $> 98\%$ in all cases. Heart rates were all within normal limits $\pm 20\%$. Inspired and end tidal concentrations of sevoflurane were between 0.1 and 0.3% for all children. No adverse incidents or side-effects were encountered.

During recovery 67 of the 69 treated children (97%) completed Eve's test [16] satisfactorily and succeeded in walking unaided within 2 min; the other two children (3%) took 5 min to perform the tests.

The mean (SD) time to discharge was 7.2 (3.1) min [range 3–15 min; Table 2].

The results of the visual analogue scale [18] for pain by children during recovery are shown in Table 3. Treatment was fully accepted by 88% of children.

The level of anxiety and co-operation [17] of children during recovery as assessed by the recovery nurse are shown in Table 4.

Sixty-eight parents (91%) regarded the overall management of their children as excellent. One 15-year-old child rated the treatment as unsatisfactory and stated that she preferred intravenous sedation, which she had been given on two previous occasions.

Of the six children whose treatment was not completed under sevoflurane inhalation conscious sedation, one cried after the extraction of three teeth and required intravenous conscious sedation with propofol to complete the fourth and last extraction; another required general anaesthesia because neither sevoflurane nor intravenous conscious sedation with propofol and midazolam made the child co-operative; and the four other children refused local anaesthetic injections and required general anaesthesia. General anaesthesia was induced with sevoflurane using a closed circuit after which a laryngeal mask airway was introduced.

Table 3 Visual analogue scale for pain (recorded by children during recovery [18]). Number (% of children completing treatment).

Child's perception of pain	
0–1 No hurt	58 (84)
2–3 Tiny hurt	8 (12)
4–5 A little more hurt	3 (4)
6–7 Hurts even more	0
8–9 Hurts a whole lot	0
10 Hurts as much as I can imagine	0
Total (completing treatment)	69

Table 4 Level of anxiety and co-operation recorded by recovery nurse (using the six-point Venham Scale [17]). Number (% of children completing treatment).

Venham scale co-operation score	
1. Relaxed	38 (55)
2. Uneasy	27 (39)
3. Tense	4 (6)
4. Reluctant	0
5. Anxious	0
6. Out of control	0
Total (completing treatment)	69

Discussion

We do not think that sevoflurane inhalation conscious sedation for children who require dental treatment has been assessed or published previously. The high failure rate of relative analgesia (40%) in children referred for anxiety management is distressing. This failure rate means that children will need either conscious intravenous sedation or general anaesthesia in order to proceed with their treatment.

An acceptable alternative to a intravenous conscious sedation technique is desirable for children with needle phobia, or when the risks of intravenous conscious sedation are considered unacceptable. Intravenous conscious sedation carries an increased risk of adverse outcome, particularly in young children. This risk is often associated with the use of more than one sedative drug even when the drugs being administered are within acceptable dose limits [19].

Sevoflurane given in a titrated concentration of between 0.1 and 0.3% in conjunction with 40% nitrous oxide in oxygen fulfils the definition of conscious sedation adopted by the General Dental Council [2]. All children in the study remained responsive to verbal commands throughout their treatment. There were no adverse side-effects observed. Kihhara *et al.* [15] investigated the awakening concentrations [mean alveolar concentration (MAC)-awake] of sevoflurane in unpremedicated children (age range 2–10 years) and reported that the mean (SD) MAC-awake of sevoflurane alone was 0.78% (0.24). The

MAC-awake of 0.1–0.3% sevoflurane and 40% nitrous oxide in oxygen was not studied. Clinical observations during this study confirmed that all children remained conscious. It is anticipated that the use of fractionated inspired sevoflurane between 0.1 and 0.3% in 40% nitrous oxide in oxygen would result in a MAC below that described by Kihhara *et al.* [15]. This technique relies on a careful titration of sevoflurane to promote anxiolysis and improve co-operation. The precise concentration required is tailored to each child's needs. We suggest that the concentration of sevoflurane should not exceed 0.3% given in 40% nitrous oxide and oxygen. Continuous monitoring of oxygen saturation, heart rate, inspired and end-tidal sevoflurane and a sedation or co-operation score [17] is essential. Because of the use of 60% oxygen, reduced oxygen saturation is unlikely with this technique. All children in the study recorded 98% oxygen saturation or above during treatment and in the recovery room.

The study showed that, of 75 children, 69 (92%) successfully completed treatment. This indicates that this technique is likely to prove more effective than inhalation conscious sedation with nitrous oxide alone. During treatment, the dentist assessed the child's level of co-operation using the Venham Scale [17]; 63 children (84%) had a score of 1 (relaxed) and six (8%) had a score of 2 (uneasy but capable of co-operating well with dental treatment). This co-operation resulted in 92% of children allowing the successful completion dental treatment. The results showed that 66 children (88%) were satisfied with the treatment and 68 parents (91%) considered that the overall treatment of their children was excellent.

All parents were instructed not to allow their children to have solid food or milky drinks for 6 h prior to treatment. Clear fluids were allowed up to 3 h before the scheduled treatment. We suggest that, for the time being, this fasting policy is maintained despite the fact that all children maintained full protective reflexes during the study.

It seems that the advantages of sevoflurane sedation are its safety, practicality, effectiveness, acceptability and cost-effectiveness. Dentists were satisfied with the quality of sedation and the extent of co-operation by the children. Sevoflurane conscious sedation meets the definition laid down by the General Dental Council [2].

Sevoflurane is not marketed for this use in the UK at present, and sevoflurane conscious sedation is not licensed or approved for general use. A large randomised controlled clinical trial for over 500 children is currently in progress to compare sevoflurane with nitrous oxide inhalation sedation.

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FORUM

Compliance with postoperative instructions: a telephone survey of 750 day surgery patients

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Summary
Patients undergoing day surgical procedures are given postoperative instructions not to drink alcohol, drive vehicles or make important decisions for 24 h. They are also advised to have a responsible adult stay with them at home overnight. Seven hundred and fifty patients were telephoned at 24 h postoperatively to determine their compliance with these instructions. Four per cent of patients drove vehicles, 1.8% consumed alcohol, while one patient made an important decision. A higher proportion of patients (5%) drove after general anaesthesia than regional anaesthesia or intravenous sedation (2.4%). The percentage of patients consuming alcohol was similar in both groups (1.8% vs. 1.9%). Four per cent of patients had no one staying with them overnight despite being accompanied out of the hospital. Patient compliance with instructions to not drink alcohol, drive or make important decisions may be improved by physician reinforcement of instructions and patient education.

Keywords *Day surgery*: ambulatory anaesthesia.

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Day surgery has experienced rapid growth in recent years, and currently accounts for $>70\%$ of all elective surgery carried out in North America. This expansion has included not only short surgical procedures on healthy patients, but also longer operations on higher risk patients.

The extremely good safety record of day surgery procedures has been a major factor in its increasing popularity. Improvements in anaesthetic and surgical techniques have contributed significantly to making procedures safer on the day surgery unit. However patients discharged from the day surgery unit are 'home-ready' but not necessarily 'street-fit'. To ensure safety, these patients are customarily given instructions not to drink alcohol, drive vehicles or make important personal decisions for 24 h following their discharge. They are also advised to have a responsible adult stay with them at home overnight.

A 1972 study of 100 surgical outpatients showed that 6% of patients ingested alcohol within 24 h of general anaesthesia and surgery [1]. Seventy-three per cent of car-owning patients drove, 9% of whom drove themselves home from hospital. In addition, 31% of patients went home unaccompanied by a responsible adult. With the present volume of day case surgical procedures and the growing popularity of office-based ambulatory surgery, the prevalence of such high rates of non-compliance may pose a safety risk. The aim of our study was to determine the current number of day surgery patients complying with postoperative instructions and to discover whether there was any difference in compliance among patients receiving general anaesthesia, regional anaesthesia and intravenous sedation. Our secondary aim was to ascertain the number of patients remaining alone at home overnight after their discharge from the day surgery unit.

Table 1 Postoperative questionnaire

1.	After your operation were you given written instructions not to drink alcohol, drive vehicles or make important personal or business decisions?
2.	What time approximately were you discharged from the day surgery unit? (24 h clock)
3.	How did you go home?
4.	Who accompanied you home?
5.	Did you have a responsible adult staying with you overnight?
6.	(If the answer to any question is yes, please ascertain approximate time – 24 h clock)
	Within 24 h of discharge from the day surgery unit did you:
	a. Drink alcohol? Yes/No/NA
	b. Drive a vehicle?
	c. Make important personal or business decisions?
	d. Use painkillers or drugs other than those prescribed? (specify type and dose)

NA = Not Applicable.

Methods

The study was approved by the institutional ethics research committee. Seven hundred and fifty adult day surgical patients, selected at random, were enrolled into the study. To avoid possible reinforcement bias, patients were told that they would be telephoned postoperatively as part of a quality control audit rather than to specifically determine postoperative compliance with instructions.

Patients with language limitations or those who were subsequently admitted as inpatients were not studied. Patients received a general anaesthetic, regional anaesthetic or intravenous sedation appropriate to the surgery being performed. The average postoperative stay on the day surgery unit was 1 h. Patients were discharged when Post-Anaesthesia Discharge Scoring System criteria were met [2]. At the time of discharge all patients were given verbal, as well as written, instructions asking them not to consume alcohol, drive vehicles or make important decisions for 24 h. Patients were also advised to have a responsible adult stay with them at home overnight.

At 24 h postoperatively, a research assistant telephoned the patients using a standardised questionnaire (Table 1). Patients were asked whether they had received written instructions not to drink alcohol, drive vehicles or make important decisions postoperatively for 24 h. Time of discharge, mode of transport home and the presence of a responsible adult with them at home overnight were also determined. Patients were also asked whether they had consumed alcohol, driven a vehicle or made important personal decisions. If a positive response was obtained to drinking or driving, patients were asked if any accidents or injuries had resulted. Patients were also questioned regarding the use of drugs and medications other than those prescribed.

Results

Seven hundred and fifty patients were contacted and responded to the questionnaire. Three per cent (23/750) claimed not to have received written postoperative instructions. Sixty-one per cent (461/750) had received general anaesthesia, 36% (254/750) received intravenous sedation and 5% (35/750) had regional anaesthesia for their surgery. Demographic data, type of surgical procedure and mode of transport to home are listed in Table 2. Cars were the most common form of transport out of the hospital, one patient took a train, one patient walked home, whereas another patient took a 1-h aircraft flight home.

Patient compliance with postoperative instructions is shown in Table 3. Two hundred and eight patients who

Table 2 Demographic data, type of surgical procedure and mode of transport home. Values are mean (SD) or number (%)

Age; years	50 (20)
Gender; male/female	313/437
Instructions received	
Yes	727 (97)
No	23 (3)
Procedures; *n* (%)	
Ophthalmic	248 (33)
Orthopaedic	240 (32)
Gynaecology	137 (18)
General surgery	44 (5.9)
Hand surgery	34 (4.5)
Urology	5 (0.7)
Neurosurgery	2 (0.3)
Chronic pain	1
Other	39 (5.2)
Mode of transport; *n* (%)	
Private car	683 (91)
Taxi	60 (8)
Bus	4 (0.5)
Train	1
Airplane	1
Walk	1

Table 3 Patient compliance with postoperative instructions 24 h post discharge

	n	%
Alcohol consumption		
Not applicable	208	–
No alcohol consumed	532	98.2
Alcohol consumed	10	1.8
Driving vehicles		
Not applicable	146	–
No vehicles driven	579	95.9
Vehicles driven	25	4.1
Decision making		
No decision made	749	99.9
Decision made	1	
Overnight companion		
Yes	721	96
No	29	4

did not normally consume alcohol were excluded from the analysis. Ten patients of 542 (1.8%) admitted to drinking alcohol within 24 h of discharge from the day surgery unit. The proportional percentage was 1.8% for general anaesthesia and 1.9% for regional anaesthesia and intravenous sedation. The mean (SD) time to alcohol consumption was 8.3 (6) h post discharge. Of the 579 patients who normally drive, 25 (4%) drove vehicles within 24 h. A larger proportion of those who had general anaesthesia drove (5%) compared with those who had regional anaesthesia and intravenous sedation (2.4%). The mean (SD) time to drive a vehicle was 13.6 (7) h after discharge. One patient made an important decision within 24 h of general anaesthesia; however, the patient refused to specify the decision made.

No patient admitted to both drinking and driving. No accidents were reported. Use of drugs or medication other than those prescribed, specifically the use of recreational drugs, was not reported by any patient. All patients were escorted out of the hospital. However, 4% (29/750) did not have a responsible adult staying with them overnight.

Discussion

Patients are customarily given instructions not to drink alcohol, drive vehicles or make important decisions for 24 h following their discharge from the day surgery unit. They are also advised to have a responsible adult stay with them overnight. These instructions have been based on various studies showing significant psychomotor and cognitive impairment after general anaesthesia [3, 4].

Patients are discharged from the day surgery unit when they are 'home-ready', that is, when they are clinically stable but need time to recover at home. However, a patient who is 'home-ready' is not necessarily 'street-fit' as complete psychomotor and cognitive recovery may not have taken place after anaesthesia and surgery. It is therefore important that patients having day surgery procedures do not drink alcohol, drive vehicles or make important decisions for at least 24 h after surgery.

Pre-operative instructions can generally be enforced at the time of admission, when there is the option of delaying or deferring surgery until all pre-operative safety criteria are met. Postoperative instructions, however, can be very difficult to enforce. In our study, 1.8% of patients consumed alcohol, 4.1% drove vehicles and one made an important decision, while 4% did not have a responsible adult staying with them at home overnight. While the overall compliance rate was better than that demonstrated by Ogg in 1972 [1], the number of patients not complying with instructions is still significant.

A number of factors could be responsible for non-compliance with postoperative instructions by patients. Instructions given may be difficult to remember or comprehend. The ability of patients to remember instructions is decreased if verbal advice is not reinforced by written instructions [5]. Studies have also demonstrated that comprehension of written material by patients is often a few grades lower than their level of education [6]. Inability to remember or understand instructions may result in non-compliance. Compliance can therefore be improved by ensuring that patients comprehend instructions. Certain units make patients sign an undertaking that they have received and understood all given postoperative instructions.

Recovery after surgery, from a patient's perspective, signifies a return to normal function. Driving vehicles or drinking alcohol could be an indication that these patients feel they have recovered with a return to daily functional activities. Patients having minor gynaecological, ophthalmic and orthopaedic surgery have recovered 81, 70 and 60% of daily functional activities, respectively, on the first postoperative day after day surgery [7]. The patient's perspective of recovery may result in non-compliance with postoperative instructions.

Lack of reinforcement of postoperative instructions could also be a factor for non-compliance. Postoperative instructions are given by nurses and are rarely reinforced by physicians. In addition, the instructions to abstain from alcohol and driving are often written together with general postoperative instructions. As a result of this, the importance of those instructions specific to anaesthesia may be lost on patients. Elaboration of the risks of non-compliance, along with written postoperative instructions and reinforcement of instructions by a physician, may increase compliance rates.

Four per cent of patients had no responsible adult staying with them overnight in spite of being escorted home from hospital; 55% of these patients were over the age of 65. As patients discharged from the day surgery unit are 'home-ready' but not 'street-fit' they should be discharged to the care of a responsible adult for 24 h postoperatively. Following the findings of our study, we have changed the policy of our unit and now record the name of an adult who will stay with the patient overnight.

With the development of new anaesthetic agents and techniques, can we reduce the recommended time of 24 h for not drinking alcohol, driving vehicles or making decisions? Lichtor *et al.* [8] demonstrated minimal interaction between midazolam and fentanyl intravenous sedation and alcohol ingested 4 h later. Sinclair *et al.* [9] showed that the mean response time on a driving simulator returned to control levels 3 h after general anaesthesia. These studies, however, were carried out using healthy volunteers. The findings cannot be extrapolated to the day surgery patient because factors such as the presence of pain and effects of analgesic drugs are not taken into account. Studies testing cognitive function, psychomotor skills and reaction times need to be carried out on day surgery patients before postoperative instructions regarding drinking alcohol, driving vehicles or making decisions can be revised.

In conclusion, in our unit, 1.8% of patients consume alcohol, 4.1% drive vehicles, while a small number make important decisions within 24 h of day surgery. A slightly higher proportion of patients (5%) drive after general anaesthesia than regional anaesthesia or intravenous sedation (2.4%). The percentage of patients drinking alcohol is similar in both groups (1.8 vs. 1.9%). Four per cent of patients did not have a responsible adult staying with them at home overnight.

Compliance with postoperative instructions can be improved by ensuring patient comprehension of advice and patient education on the dangers of non-compliance. Instructions also need to be reinforced by the attending physician.

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