The lumbar extradural structure changes with increasing age

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Summary
We have examined the extradural space using a flexible extraduroscope in 74 patients undergoing extradural anaesthesia at the L2–3 interspace. Extraduroscopy showed that the extradural space becomes widely patent and the fatty tissue in the extradural space diminishes with increasing age. We postulate that these age-related structural changes may affect the spread of local anaesthetic in the extradural space. (British Journal of Anaesthesia 1997; 78: 149–152).

Key words

Many investigators have described the effects of ageing on extradural dose requirements in lumbar extradural anaesthesia.1–4 Some authors have reported a reduction in lumbar extradural dose requirements with age,1,3 while others have found that age has little or no effect on the spread of lumbar extradural anaesthesia.4 However, the reasons for the increase in cephalad spread of extradural analgesia in the elderly have not been investigated thoroughly. Several age-related factors may contribute to the extensive spread of local anaesthetics, especially in the elderly, including arteriosclerosis, decreased neural population5,6 and increased compliance of the extradural space.7 The changes in the structure of the extradural space with increasing age may affect cephalad spread of local anaesthetics in the extradural space. Because extraduroscopy can provide a clear view of the lumbar extradural space,6,9 we used this technique to investigate the effects of age on the structure of the extradural space.

Patients and methods
This study was approved by our local Ethics Committee and informed consent was obtained from all patients. We examined the lumbar extradural space using a flexible fibrescope in 76 patients undergoing lumbar extradural anaesthesia for a variety of surgical or therapeutic procedures, including hysterectomy, oophorectomy, knee arthroscopy, total knee arthroplasty, total hip arthroplasty, extracorporeal shock-wave lithotripsy, transurethral resection of the prostate and transurethral resection of bladder tumours. Pregnant women and patients with a history of prior extradural anaesthesia, neurological disease or abnormalities of the vertebral column were excluded. Each patient was premedicated with hydroxyzine 25–50 mg. The patient was then placed in the right lateral decubitus position on a horizontal operating table. A 17-gauge Tuohy needle was introduced at the L2–3 interspace using the paramedian technique. The extradural space was identified using the loss-of-resistance method with 5 ml of air. When no cerebrospinal fluid or blood flowed from the needle, the patient underwent examination of the lumbar extradural space with a flexible fibrescope measuring 0.7 mm in diameter (MS-501, Igarashi Ika Kogyo Co., Tokyo, Japan) which was connected to a television monitor system (FV-2000E, Igarashi Ika Kogyo Co., Tokyo, Japan). The extraduroscope was introduced approximately 10 cm in a cephalad direction into the extradural space via the Tuohy needle. No more air was injected after insertion of the extraduroscope in each patient. If paraesthesia or resistance were noted during insertion of the extraduroscope, no attempt was made to advance the extraduroscope through the area of resistance. Consequently, two patients in whom the extraduroscope could not be advanced more than 5 cm cephalad were excluded from analysis. Extraduroscopic findings were recorded continuously on a video recorder during the examination in each patient. After extraduroscopic examination, an extradural catheter (external diameter 0.85 mm; B. Brown, Bethlehem PA, USA) was inserted 5 cm cephalad into the extradural space and the patient was then placed in the supine position. All procedures were performed by the same anaesthetist. Patients received local anaesthetic via the catheter during the planned therapeutic or surgical procedure, with or without general anaesthesia, used in combination.

The extraduroscopic findings in our 74 patients were analysed by two independent investigators who were blinded to the patients’ medical histories. Extraduroscopic findings were divided into five groups.

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categories for analysis: patency of the extradural space, amount of fatty tissue, amount of fibrous connective tissue, degree of vascularity and blood vessel trauma at the tip of the Tuohy needle. The patency of the extradural space was scored using the following grading system: 1 = extremely narrow, 2 = patent and 3 = widely patent. The other four findings were scored using the following grading system: 1 = none, 2 = moderate and 3 = extensive. When a discrepancy between two observers in each finding was noted, this difference was resolved by a third experienced investigator to reach consensus.

Statistical analyses were carried out using a statistical software package (StatView V4.02, Abacus Concepts, CA, USA) on a personal computer (Macintosh Quadra 650, Apple Computer, Inc., CA, USA). The relationship between age and each extraduroscopic finding was analysed by Spearman’s correlation coefficient by rank. Relationship between age and each extraduroscopic finding was analysed by the Kruskal–Wallis test and Mann–Whitney’s U test. P < 0.05 was considered statistically significant.

**Results**

Mean age, height and weight were 51 (range 23–81) yr, 157 (SD 8) cm and 56 (9) kg, respectively (table 1).

Extraduroscopic examination (table 2) revealed significant correlations between age and the patency of the extradural space (ρ = 0.33, P = 0.02) and the amount of fatty tissue (ρ = –0.28, P = 0.004). Amount of fibrous connective tissue, degree of vascularity and blood vessel trauma were not related to age. None of the extraduroscopic findings in this study showed correlations with height, weight, body mass index or body surface area. With regard to patency, mean age was significantly higher in patients who scored 3 than in patients who scored 1 or 2 (table 3). With regard to the amount of fatty tissue, mean age was significantly lower in patients who scored 3 than in patients who scored 1 or 2. Blood vessel trauma at the site of the Tuohy needle in the extradural space was observed in 21 (28%) patients, all of whom were scored as grade 2, on the fatty tissue, dura mater or periosteal layer. There was no productive or massive bleeding which occupied the extradural space. None of the blood vessels was injured by the extraduroscope at a site distant from the Tuohy needle.

Figure 1 shows typical extraduroscopic findings in elderly patients. The extradural space in a 77-yr-old man was observed as a widely patent canal (A). Fatty tissue is seen to have been torn from the dura mater by the air injected into the extradural space as the extraduroscope is advanced (B). Fibrous connective tissues extend across the patent canal. In this patient, the patency of the extradural space, amount of fatty tissue, amount of fibrous connective tissue and degree of vascularity were scored as 3, 2, 3 and 1, respectively.

**Figure 1** Photographs obtained via the extraduroscope in a 77-yr-old man. The extradural space is observed as a widely patent canal (A). Fatty tissue is seen to have been torn from the dura mater by the air injected into the extradural space as the extraduroscope is advanced (B). Fibrous connective tissues extend across the patent canal. In this patient, the patency of the extradural space, amount of fatty tissue, amount of fibrous connective tissue and degree of vascularity were scored as 3, 2, 3 and 1, respectively.
connective tissue was seen between the dura mater and the periosteal layer. In the same patient, fatty tissue was observed in the extradural space as the extraduroscope was advanced (fig. 1B). The left part of the canal was identified as the dura mater with its associated blood vessels and the right part of the canal was identified as fatty tissue associated with the periosteal layer. In this region, fatty tissue was seen to have been torn away from the dura mater by the air injected into the extradural space and fibrous connective tissue was seen extending across the patent canal. In this patient, patency of the extradural space, amount of fatty tissue, amount of fibrous connective tissue and degree of vascularity were scored as 3, 2, 3 and 1, respectively.

Figure 2 shows typical extraduroscopic findings in young patients. A narrow extradural space created by the injected air is seen in the right, lower part of the photograph obtained in a 26-yr-old man (fig. 2A). The left part of the canal appears as a white membrane with associated blood vessels and was identified as the dura mater. The outer area on the right side of the photograph was identified as fatty tissue with blood vessels. The extradural canal appeared to be very short and narrow because of the presence of a large amount of fatty tissue (fig. 2B). The fatty tissue was seen to be under tension and tightly adherent to the dura mater or the periosteal layer beyond the fibrous connective tissue. In this patient, the patency of the extradural space, amount of fatty tissue, amount of fibrous connective tissue and degree of vascularity were scored as 2, 3, 3 and 2, respectively.

We encountered no accidental dural punctures and observed no signs of persistent neurological injury in any of our patients.

Discussion

In this study, extraduroscopic examination revealed that the amount of fatty tissue was reduced and the extradural space became widely patent with increasing age. We postulate that the amount of fatty tissue in the lumbar extradural space may play an important role in determining the patency of the extradural space, thereby affecting the longitudinal spread of anaesthetic solutions in the elderly.\(^1\)\(^-\)\(^3\)

We found that the patency of the extradural space, after injection of 5 ml of air into the extradural space, became greater with increasing age. Our results on the patency of the extradural space may be related to the fact that the compliance of the extradural space increases with advancing age.\(^7\)

Another extraduroscopic finding was that the amount of fatty tissue was related inversely to increasing age. This may be one reason for the changes in patency of the extradural space in the elderly. As the fatty tissue degenerates with advancing age, the extradural space becomes more compliant, resulting in the observed changes in the patent of the extradural space. In addition, our results demonstrated that the extradural space in young patients was packed tightly with rigid fat\(^10\) and showed low compliance.

Connective tissues other than fatty tissue were observed as strands or membranes in the extradural space and were not found to be related to age. These connective tissues are found between the fatty tissue, dura mater and periosteal layer. Although these connective tissues were thought to be important factors related to compliance of the extradural space, we did not find age-related differences in fibrous connective tissues. Because these fibrous connective tissues were more fragile than the fatty tissue, they may have been stretched and broken by the air introduced into the extradural space. If the amount of air introduced into the extradural space was more or less than 5 ml, it may be possible to demonstrate statistically significant changes in the amount of fibrous connective tissue with increasing age.

In assessing the results of this study, we must consider several factors that may have affected our results. The extradural space was observed after introducing a small amount of air. The extradural space is sometimes described as a potential space, rather than a true cavity.\(^9\)\(^,\)\(^11\)\(^,\)\(^12\) The introduction of air may therefore have affected our extraduroscopic findings, expanding the extradural space and stretching the connective tissues. However, in our study, all patients received identical extradural punctures and
the effects of air introduced into the extradural space should have been comparable in all cases. Therefore, we believe that this factor had no influence on our comparative findings.

We observed fatty tissue in a segmental distribution in the extradural space as the extraduroscope was advanced in a cephalad direction. That the extradural fatty tissue is divided into segments by interposed laminae in the lower thoracic and lumbar regions has been demonstrated by sagittal midline magnetic resonance imaging. In this study, extradural structures were observed mainly from the point where the fatty tissue ceased to exist. We did not divide our extraduroscopic findings into two separate categories based on the presence or absence of fatty tissue because the patency of the extradural space tended to be similar regardless of the presence of fatty tissue.

In the lower thoracic and lumbar segments, it has been suggested that the extradural space is divided transversely into three compartments: anterior, dorsal and dorsolateral. Unfortunately, we were not able to determine which of the three compartments of the extradural space was observed in this study. In some cases the extraduroscopic findings showed the compartments of the extradural space to be incompletely separated by thin and fragile membranes. Our extraduroscopic procedures were performed by the same anaesthetist and the tip of the Tuohy needle was introduced into the extradural space as precisely as possible in the midline. However, differences between the three compartments in terms of extraduroscopic findings have not yet been clarified, and these differences may have affected our findings.

Several technical problems were encountered during the procedure. Nerve root irritation during insertion of the extraduroscope may be related to technical problems with extradural puncture. The cord or nerve roots may be compressed during insertion of the extraduroscope, which is more rigid than the extradural catheter. Although extradural punctures were performed using the same procedures employing the paramedian technique, the angle of the needle relative to the dorsal plane of the skin may have varied from patient to patient. We postulate that the greater the cephalad angle of the needle relative to the dorsal plane of the skin, the lower the incidence of nerve root irritation. Indeed, in patients who experienced nerve root irritation during insertion of the extraduroscope, repeat attempts with a greater needle angle made it possible to insert the extraduroscope into the extradural space without eliciting nerve root irritation. Therefore, the cephalad angle of the Tuohy needle relative to the dorsal plane of the skin appears to be a very important consideration in performing extraduroscopy without nerve root irritation. Although none of our patients who experienced nerve root irritation suffered permanent neurological injury, care should be taken not to damage the nerve roots or cord when irritation is encountered during extraduroscopic examinations.

We observed blood vessel trauma induced by the introduction of the Tuohy needle into the extradural space in approximately 25% of all patients. Arteriosclerosis is seen frequently in the elderly, and the incidence of blood vessel trauma might therefore be expected to increase with advancing age. However, the incidence of blood vessel trauma by the tip of Tuohy needle was not found to be related to age. Blood vessel trauma was observed on the fatty tissue, dura mater and periosteal layer by the tip of Tuohy needle in the extradural space. However, we observed no productive or massive bleeding which was filled with the extradural space. Although we sometimes experience intravascular migration of an extradural catheter in clinical practice, it remains unknown in which vessels the extradural catheter is misplaced.

References