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In Reply:—In reply to Drs. Blomberg and Huson, I must admit that certain restrictions on soft tissue resolution are imposed by the use of wide window CT imaging (2000–4000 H.U.) as required in CT-peridurography. The dorso-median dural fold and its ligamentous attachments become indistinguishable in these wide grey scale images. Likewise, the dorsolateral connective tissue planes and their fibroadipose contents are of one density outlined only by the concentrated radiographic contrast material in the adjacent epidural compartments. Consequently, the juncture of the "dorsomedian ligamentous band" and the "dorsomedian dural fold" is not clearly seen.

We have noted the absence of the dorsomedian dural fold in the physiological state in magnetic resonance imaging (MRI) of the lumbar spine. The dorsomedian ligamentous band and dorsolateral connective tissue planes also are not seen, but are apparently obscured by the high radiosignal of fat in the epidural space.

The division of the dorsolateral epidural space into separate anterior and posterior compartments was seen in all 40 of our CT-epidurograms; however, the triangular configuration of the connective tissue junctions was seen in only 31 of the examinations. The CT scans would consist of 30 or more consecutive axial sections at 3 mm intervals, extending from L3 through S1 vertebral levels.

At fluoroscopy, unilateral filling of the posterior epidural space might progress over two or three vertebral levels before filling of the contralateral space would occur. For this reason, we used a curved catheter to distribute the contrast material equally between the right and left posterior spaces in our diagnostic studies. Similarly, as seen on CT, the anterior or posterior compartment of one side might fill preferentially over one to two vertebral levels before filling of the adjacent compartment would occur. Consequently, while the compartments freely communicate, the tendency of this degree of preferential filling would indicate more than connective tissue planes composed of fibrous strands alone.

At dissection, however, only the dorsomedian connective tissue band would resist tearing produced by traction on the dura. The delicate nature of the lateral membranous connective tissue planes may explain the lack of their demonstration on epiduroscopy and in epidural casts in cadavers.

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The Use of PEEP in Patients in the Sitting Position

To the Editor:—The contribution of Dr. Zasslow *et al.*[1] to the discussion and understanding of the phenomenon of paradoxical venous air embolism (PVAE) was most welcome. However, while I doubt it was their intention, I am concerned that the report may be misinterpreted by some as advocacy of the use of PEEP during procedures performed upon patients in the sitting position. It should not be viewed as such. The limitations of the study, some of which are acknowledged by the authors, and other considerations relevant to the use of PEEP should be fully appreciated.

Zasslow *et al.* measured right atrial pressure (RAP) and pulmonary capillary wedge pressure (the latter as an index of left atrial pressure [LAP]) during the application of PEEP in patients undergoing surgical procedures in the sitting position. A positive RAP-LAP gradient (*i.e.*, RAP > LAP) occurred infrequently during the application of 10 cm H_2O of PEEP. This was in contrast to the incidence reported by other investigators.[2,3] In support of their observations, Zasslow *et al.* introduce a discussion of the manner in which PEEP might be anticipated to influence the RAP-LAP pressure gradient.

Previous observations made during deliberate attempts to provoke right atrial to left atrial shunting (for the purpose of identifiying patients at risk for PVAE) may be relevant to this discussion. In both unanesthetized[4] and anesthetized[5] patients, maneuvers which generated positive airway pressures were observed to provoke right-to-left shunting, apparently principally during the phase immediately following the release of airway pressure. The investigation by Cucchiara *et al.*[5] of anesthetized subjects also sought evidence of right-to-left shunting at the time of end expiration (no PEEP). Right-to-left shunting at end expiration was not observed in any patient, including those in whom it had been seen in the release phase following positive airway pressure. These observations raise two questions with respect to the report of Zasslow *et al.* The first relates to the timing of the RAP and LAP measurements. These measurements were performed by Zasslow *et al.* at end expiration. The reports mentioned above[4,5] suggest that a positive RAP-LAP gradient is more likely to occur early in the expiratory phase. Accordingly, the data of Zasslow *et al.* as well as that of others[2,3] may underestimate the actual incidence of positive RAP-LAP gradients. The second question is whether the peak pressure achieved during a positive airway pressure maneuver is an important variable in determining the frequency or volume of shunting. Neither study mentioned above[4,5] attempted to examine this relationship, and the answer is accordingly a matter of speculation. However, it is reasonable to be concerned that PEEP, which inevitably increases the peak airway pressure achieved with each inspiratory phase, might increase the likelihood of a positive RAP-LAP gradient during the subsequent expiratory phase. Because of these questions, I doubt that investigations of the influence of PEEP on the potential for the occurrence of PVAE should be viewed as complete, or that PEEP should be absolved as a risk factor for PVAE without an evaluation of the RAP-LAP gradient during the entire respiratory cycle.

An additional minor point arises from that same discussion of the manner in which PEEP might be expected to alter the right atrial to left atrial gradient. Zasslow *et al.* argue that the intrathoracic pressures generated as a result of the application of PEEP should be transmitted equally to both atria. This is almost certainly the case. However, the effects on the vascular resistances confronting the two ventricles may differ substantially. The data of Zasslow *et al.* indicate that the application of 10 cm of PEEP resulted in a 50% increase in pulmonary vascular resistance, but were simultaneously accompanied by a very

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