LABORATORY REPORT

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Multiport Epidural Catheters

Can Orifice Location Be Tested?

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EPIDURAL anesthesia test doses have been designed assuming that the entire test dose will exit *via* the malpositioned catheter orifice.[1-4] However, triple-orifice catheters have three potential exit paths. Numerous studies report radiographically proven, clinically significant placement of triple-orifice catheter holes into two different body compartments: epidurovascular,[5] epidurosubdural,[6,7] or epidurointrathecal.[5,8,9]

The distal hole is the one most likely to be located outside the epidural space in a two-compartment catheter placement because malposition of only the middle or the proximal hole necessitates that the vessel wall or the dura be punctured twice. Slowly injected fluids preferentially exit the most proximal multiport catheter hole while approximately equal fluid volumes exit each hole during rapid injection.[10] Effective epidural test doses must test the distal hole.

The minimum injection speed needed to obtain flow through all three catheter ports (threshold speed) varies with catheter diameter.[10] Threshold speed has not been reported for commercially available, 20-gauge, triple-holed catheters, the most frequently sold epidural catheters in the United States (C. DiBase, B. Braun Medical, Inc., Bethelehem, PA; personal written communication, December 9, 1997). We found no quantitative information regarding the pressure differential between epidural veins and the epidural space; however, cerebrospinal fluid pressure is 1.7-15 mmHg higher than resting epidural space pressure.[11,12] Therefore, we determined the threshold speed for distal orifice flow in 20-gauge, multiport, epidural catheters with 0, 1, 2, or 3 orifices under 10-20 cm saline (7.4 or 14.7 mmHg) using air and saline injectates.

Methods

We obtained commercially available, unfiltered, 20-gauge, three-orifice nylon catheters from two manufacturers: Braun (B. Braun Medical; n = 4) and Portex (Sims Portex, Inc, Keene, NH; n = 6). Catheters were inspected during saline injection. We did not test catheters that did not have three holes or in which there was obvious asymmetry of hole size. We used a metronome to regulate injection speed while we injected by hand. One investigator observed the pattern of flow through the catheter ports, while a second investigator set the metronome and performed the injection using a 3-ml syringe. We verified the accuracy of the metronome at 40, 60, 80, 120, and 160 beats/min using a stopwatch. The catheter was always held horizontally, with the distal orifice facing toward the floor.

We inserted six catheters (three Portex, three B.

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Table 1. Threshold Speed Needed for Injectate Flow through all Three Catheter Holes (ml/s)

Injectate (external saline pressure)	Number of Orifices under Pressure			
	0	1	2	3
Saline				
10 cm	0.06	0.07	0.05	0.006
20 cm	0.06	0.1	0.08	0.006
Air				
10 cm	—	3	3	2
20 cm	—	4	3	2

Braun) into 1-l bags of normal saline intended for intravenous use. The catheters were inserted through 20-gauge holes placed 10 or 20 cm below the saline meniscus. In separate experiments, each catheter was tested at 10 and 20 cm depths. Each catheter was sequentially positioned with zero, one, two, or three orifices in the normal-saline bag. We determined the slowest speed at which air or normal saline colored with food coloring exited through all three orifices. We injected at this minimum speed and at slightly faster and slower speeds three times for each catheter and during each condition to verify the results.

Results

Two catheters lacked orifices: one Portex catheter had no orifices and one Braun catheter had two orifices. Two Portex catheters had one hole that was much smaller than the other two. These four catheters were not tested further.

Data for the catheters from the two manufacturers did not differ and were combined (table 1). The required injection speed for flow through all three holes increased as the number of externally pressurized orifices decreased. Required speeds were 37–333 times faster for air than for saline.

Discussion

During saline injection, the threshold speeds needed for flow through all three holes were extremely slow. One would ordinarily hand-inject an epidural test dose faster than these threshold speeds. However, the threshold speeds for air were 2–4 ml/s, which may be impractically fast. For both air and saline, the speeds needed to detect malposition of one or two orifices were faster than the speeds required to detect three malpositioned holes.

Falsely reassuring test-dose results could be obtained if a malpositioned catheter orifice was blocked during epidural test-dose injection. Obstructed orifices are not rare; Collier and Gatt[13] injected saline through 36 multiport catheters immediately after removing them from patients and found that 7 (19%) had one or more blocked orifices. An orifice that is obstructed by clot or tissue during gentle test-dose administration could be cleared subsequently by forceful injection. Slowly injected air might not exit a malpositioned distal hole. An obstructing catheter kink could later be straightened deliberately or inadvertently by catheter withdrawal, which could change the injectate flow pattern. One such case, with a fatal outcome, has been reported.[8] Falsely reassuring data are worse than no information because the clinician may then incorrectly assume that all orifices are epidurally located and rapidly inject a dangerously large drug dose.

Even if these physical problems were solved, no test dose with a sufficiently large therapeutic range exists. An ideal test dose would be sensitive enough to detect one malpositioned hole, yet safe if all three holes were malpositioned. If injected sufficiently rapidly, approximately one third of a test dose should exit each hole. Thus, the ideal multiport catheter test dose needs at least a threefold therapeutic range for architectural reasons, in addition to the range necessitated by interpatient variability. The therapeutic range for single-orifice catheter test doses is determined only by patient variability because everything injected at the hub exits the single hole. Yet controversy still exists regarding the best way to test single-orifice catheters.[1–4] It seems unlikely that test doses with cardiovascular endpoints, such as epinephrine or isoproterenol, will prove to be safe and sensitive enough for multiport epidural catheter use.

Multiorifice epidural catheters are inserted intravascularly in 6–12% of patients.[5,14] Because of the problems of detecting these malpositions, this incidence is unacceptably high. Future research should concentrate on developing catheters and insertion techniques that minimize blood vessel puncture. Such research would be greatly facilitated by the very thing we now lack: a safe, inexpensive, effective, nonradiographic way to detect intravascularly located epidural catheters.

We found manufacturing defects in 4 of the 10 catheters we tested. One catheter had no orifices, one catheter had two orifices, and two catheters had obvious orifice asymmetry. A high rate of manufacturer defects decreases the benefits of multiorifice design.

Can one test the location of all orifices of a triple-holed catheter? Unfortunately, the answer is no. The distal hole is the one most likely to be malpositioned, yet saline and air preferentially exit the proximal hole. One or more orifices could be dangerously malpositioned yet temporarily blocked during catheter testing. Even if these problems were solved, no test dose is available with a large enough therapeutic range to be safe and effective for multiport catheter use. Multiport catheters have a good clinical safety record. However, until better catheters or better testing methods are developed, every dose injected through a multiport epidural catheter must be a test dose.

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