EQUIPMENT, MONITORING, AND ENGINEERING I

Title: A COMPARISON OF LEFT VS. RIGHT PARASTERNAL DOPPLER PLACEMENT FOR DETECTION OF VENOUS AIR EMBOLISM

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Introduction: Recommendations for positioning a precardial Doppler probe during procedures associated with the risk of venous air embolism (VAE) have emphasized probe placement between the third and sixth intercostal spaces along the right parasternal border. Clinical experience and evidence in the literature suggest that successful Doppler placement can be difficult when using this approach, particularly in obese patients or in those with abundant breast tissue. Frequently, an acceptable Doppler signal is more easily obtained along the left parasternal or paracardiac areas. However, the validity of left parasternal Doppler placement for VAE monitoring has been questioned, since a probe positioned to the left of the sternum could conceivably miss air bubbles traveling the right heart. In order to clarify this issue, we compared the response of a left parasternal probe with a conventionally placed probe to IV test injections of normal saline (NS) and carbon dioxide (CO2).

Methods: With institutional approval and informed consent, we studied 23 patients (age range 18-77 years) undergoing elective craniotomy. After induction of anesthesia and tracheal intubation, the lungs were mechanically ventilated at tidal volumes of 10 ml/kg. A multi-needle central venous catheter (Bumengin-Abin Air Aspiration Set, Cook, Inc.) was inserted via the antecubital route, with the tip positioned at the SVC-atrial junction, using intraocular electrocardiography. Doppler sounds were simultaneously monitored with two P-81 ultrasound probes attached to two separate Versatone units (Medsonics Inc.). Probe R was placed at the conventional location along the right parasternal border. Probe L was positioned along the left parasternal border between the third and sixth intercostal spaces. Both probes were secured with adhesive tape. All subjects then received a predetermined and systematically varied sequence of four IV injections of room temperature NS (10 ml) and CO2 (1 ml) given via the central and peripheral (16g, forearm) venous catheters. All injections were made by the same investigator using the same technique (rapid hand injections through a stopcock positioned 50 cm proximal to the hub of either catheter through which a continuous crystalloid infusion was maintained at 200-300 ml/hr). After each injection, Doppler sounds were allowed to return to normal with a minimum of 3 minutes elapsing between injections. All injections were made with the patient in the semi-recumbent position and were completed prior to headholder placement and incision. Simultaneous audiotope recordings of the electrical output of each of the two Versatone units were made. At the conclusion of the study period, probe R was left in place for clinical monitoring during the case. Doppler responses to test injections were later graded as either positive or negative by experienced observers blinded to probe position and type of test injection. Statistical analysis utilized the chi-square method and Fisher's exact test where necessary. Statistical significance was accepted if p<0.05.

Results: An adequate right parasternal Doppler signal was obtained in only 18 of 23 patients (78%), whereas the left parasternal Doppler signal was easily obtainable in all patients. The frequency of positive responses at probes R and L to the four test injections appears in the table. For all test modalities except peripherally injected CO2, probe L always yielded a positive response whenever probe R did. In no case was probe L negative when probe R showed a positive response, but in several patients probe L detected a response to test injections when probe R did not. Although the frequency of positive response was higher at probe L vs. probe R for all four test injections, this trend did not achieve statistical significance. With the exception of NS at probe L, peripherally injected test boluses failed to generate a sufficient number of positive responses to be useful for routine verification of probe placement. In one patient, subsequent to the study period, the conventionally placed Doppler probe (R) failed to detect a VAE event during craniotomy (confirmed by appropriate changes in end-tidal CO2 and nitrogen concentrations). Analysis of the audiotope for this patient revealed that probe A had been silent to test injections while probe B had not.

Discussion: Our data indicate that left parasternal Doppler placement is at least as efficient in responding to test injections as a right parasternal placement. Based on the ease with which the left parasternal Doppler signal could be found, the high verification rates with bolus NS (central and peripheral) and CO2 (central) and the failure of a conventionally placed probe to detect a clinical VAE event, it is suggested that a Doppler probe in the left parasternal area represents a reasonable alternative placement along the right parasternal area and may, in some instances, even be preferable.

References:
2. Tinkler JH, Gronert GA, Messick JM, Michenfelder JD: Detection of air embolism, a test for positioning of right atrial catheter and Doppler probe. Anesthesiology 43:1041056, 1975

| TABLE: Positive Doppler responses (%) to different test injections |
|---|---|---|---|---|
| (n=18) | Central NS | Central CO2 | Periph. NS | Periph. CO2 |
| PROBE R | 17(40) | 13(32) | 10(50) | 7(39) |
| PROBE L | 18(100) | 16(39) | 15(83) | 9(50) |

* All L vs. R comparisons ns.