Title : MONITORING OF CARDIAC OUTPUT BY PULSED DOPPLER AORTIC IMPLANTABLE MICROPROBES AFTER CARDIAC SURGERY

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Introduction: In cardiac units, monitoring of cardiac output (CO) is essential for diagnosis and treatment. For this purpose right heart catheterization with thermodilution clearance (TDCO) are extensively used in intensive care units. The accuracy of TDCO can be affected by: the bolus temperature and volume, the position of the thermistor, the respiratory cycle during mechanical ventilation[1]. Thus, an easy to use, non invasive and reliable method would be of considerable interest in the management of such patients. CO was already measured by echo-Doppler method, either via esophageal or suprasternal probes[2]. The former cannot be used for a long time and measures only descending aortic blood flow. The latter is technically difficult after cardiac surgery, because of the presence of air or blood in the mediastine.
Those limitations led us to develop a new implantable aortic pulsed Doppler microprobe to monitor CO after cardiac surgery. In this study, pulsed Doppler cardiac output (PDCO) was compared to simultaneous TDCO.

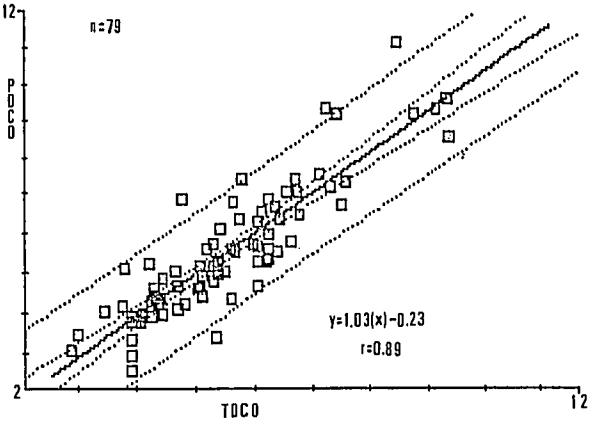
Methods: 10 patients (55 ± 7 yrs SD) were included. Written informed consent was obtained prior to the study and protocol was approved by the Local Ethical Committee. 79 measurements were performed in hemodynamic steady state, with or without inotropic or vaso-active drugs, during spontaneous or mechanical ventilation (with or without PEEP). TDCO was measured using a triple lumen Swan-Ganz catheter. For each measurement, TDCO was the average of 5 bolus injections of cold saline in random order during the respiratory cycle. For PDCO measurement, we used a zero-crosser pulsed Doppler velocimeter with an ultrasound frequency of 4 MHz and a pulse repetition of 10 kHz. This apparatus provides the ability to select a period of the reflected signal using a time electronic gate. This allows an exact determination of the sample volume size and depth from the transducer. For aortic PDCO, the sample volume was the smallest compatible with an acceptable signal to noise ratio. To measure the ascending aortic blood flow, the microprobe was positioned above the aortic valves during cardiac surgery; when the best audio and visual signal was obtained, the microprobe was fixed by 4 sutures through the adventitia and the silicone of the probe.

The probe consisted in a piezoelectric crystal soldered on a silicone prism, connected by 80 cm leads lenght to the apparatus. The prism was cut in such manner that the angle between the ultrasonic beam and the vessel axis was 60 °.

Six days later, the probe was removed by a simple traction, without any damage for the patient. To compute CO on ascending aorta on a beat-to-beat basis, following parameters are needed : 1) mean blood velocity (BV), averaged from 10 successive cardiac cycles in order to minimize the influence of ventilation ; 2) mean cross-sectionnal area (CSA = $\Pi D^2/4$, where D is the average systolic diameter of the ascending aorta, determined by a 2-D echo in the preoperative period); 3) heart rate. PDCO was computed from : PDCO = BV x HR x CSA in l/min.

Results: The average ascending aorta diameter was 3.2 ± .24 cm. The figure shows the correlation between the two CO techniques. The linear regression equation was : PDCO = 1.03 TDCO - .23, with r = 0.89; $p<0.001$. The mean difference between TDCO and PDCO for all 79 measurements was 10.7 %.

Discussion:
Implantable aortic pulsed Doppler microprobe is a safe, accurate and simple technique for CO monitoring after cardiac surgery. Even if zero crossing analysis is an old method, it provides adequate signals in this case, because of the incidence angle (60°) and the short distance between the crystal and the blood. Furthermore, the sample volume moves with the aortic displacement, so that measurements are always in the same depth. The CO range studied was large and sufficient for the post operative situations. Finally this technique authorized CO measurements over a 6 days period.



REFERENCES :
1- CONNORS AF, Mc CAFFREE DR, GRAY BA: N. Engl. J. MED. 308, 263-267, 1983
2- BENNETT ED, BARCLAY SA, DAVIES AL et al: Cardiovasc. Res. 18, 632-638, 1984