TITLE: LIMITATIONS OF THERMAL DILUTION EJECTION FRACTION: PERFORMANCE OF CATHETER MOUNTED THERMISTORS

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Introduction: Measurement of ventricular ejection fraction (EF) is useful in characterizing ventricular function and the value of EF is used in the calculation of ventricular volume. Recent studies report thermal dilution ejection fraction measurement using right ventricular injection of cold liquid and a catheter mounted fast response thermistor (FRT) to record the resulting staircase temperature curve in the pulmonary artery.[1] This study was undertaken to determine if catheter mounting impairs the ability of FRT to register temperature change with a degree of fidelity necessary for the measurement of ejection fraction from thermal dilution curves.

Methods: The time constant (τ) of 6 FRT mounted on 2 Elecath (EL) and 4 Edwards Laboratories (ED) 7Fr "ejection fraction" pulmonary artery catheters and of a bare, unmounted FRT (Thermometrics P20 series) was measured. τ is the time required for the FRT to register 63% of a step change in temperature (99% change occurs in 5 τ). The FRT was mounted laterally with a minimum of potting material on the catheters designated ED 1, ED 2, EL 1 and EL 2. In a different mounting configuration, the FRT bead partially protruded from a special depression cut into the catheter wall of ED 3 and ED 4. Each catheter mounted FRT and the bare unmounted P20 FRT was equilibrated at room temperature (15°C) and then plunged into a 37°C water bath. A system of two unfiltered Wheatstone bridge amplifiers and Irex System II optical recorder (system frequency response to square wave resistance change was less than 1 msec) permitted simultaneous measurement of the response of bare and catheter mounted FRT to the 15°-37°C square wave temperature change. To evaluate the impact on EF measurement of slowing of catheter mounted FRT response, the bare P20 FRT and catheter mounted ED 2 FRT were placed downstream from a valved, pulsatile model ventricle.[2] Stroke volume and rate were constant, and EF was independently set at 0.25 and 0.33. Six 5 ml injections of 0°C water were made directly into the model ventricle while pumping 37°C water. TD curves recorded from the FRT were A/D converted and stored by an HP9845B computer for calculation of $EF=1-(\Delta Tn+1/\Delta Tn)$ where Δ Tn and $\Delta Tn+1$ are differences between baseline temperature (T) and the T at beats n and n+1 (T was taken from the plateaus of the descending limb of the curve and at least 3 EF values (4 beats) from each curve were averaged). Mean EF±SD for the six curves was calculated, and the percent difference was calculated between EF measured from the unmounted P20 and catheter mounted ED 2 FRT.

Thermistor Type	τ msec	% of Step Change 0.5 sec	1 sec
P20	25	100	100
ED 1	98	86	88
ED 2	79	86	88
ED 3	113	84	90
ED 4	150	82	91
EL 1	100	90	94
EL 2	113	92	96

TABLE 1: FRT Response to step change in temperature presented as τ and as percent of 15°-37°C. change achieved in 0.5 and 1.0 second.

Results: The τ measurements in this study are presented in Table 1 and are consistent with those reported by the manufacturers of the catheters. However, the standard τ measurement does not indicate the length of time required by catheter mounted FRT to equilibrate to a step change in temperature. In clinical practice it is the time to equilibration to a new temperature that is reflected in the accuracy of measuring the temperature plateaus of the descending limb of thermal dilution curves. Table 1 makes clear that at 0.5 second and 1 second (needed response time for heart rates of 120 and 60 beats/minutes), catheter mounted FRT are not equilibrated to the new temperature.

Simultaneous curves obtained from the model ventricle with P20 and ED 2 FRT are presented in Figure 1. The P20 FRT curve is of higher fidelity with larger step changes and more rapid decay (actually crossing the ED 2 curve at point X). In the pulsatile model, the EF values measured with catheter mounted FRT were 13.9 ± 6.6% (EF setting 0.25) and 16.5 ± 2.5% (EF setting 0.33) lower than EF measured with bare FRT P20.

Discussion: The response of a catheter mounted FRT to a rapid temperature change is distorted when compared to that of a bare FRT. The effect is to artifactually lower thermal dilution EF measurements below the true EF value. It is concluded that catheter mounting degrades response of FRT to an extent that EF will not be measured accurately from the plateaus of the descending limb of TD curves unless the measurement is corrected for the damping effect of the catheter body.

References:
1. Rao TLK, El-Etr AA: Role of pericardium on right ventricular performance. Anes 59:A5, 1983.
2. Maruschak GF, Schauble JF and Rogers MC: Ejection fraction by thermodilution. Anes 55:A112, 1981.

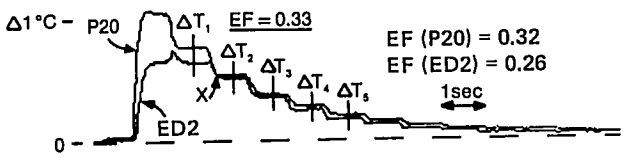

FIGURE 1: Thermal dilution curves from model ventricle with known EF 0.33. Measured EF with P20 and ED 2 FRT differ by 19% in this example.