Title: EFFECT OF THE DYNAMIC RESPONSE OF TRANSDUCER-TUBING SYSTEM ON ACCURACY OF DIRECT BLOOD PRESSURE MEASUREMENT

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Introduction. The use of long, low compliance tubing (48-60 inches) to connect arterial cannula to transducer, adversely affects the fidelity and accuracy of reproduction of the blood pressure signal that is being measured.[1] The fluid-filled transducer-tubing system (TTS) is affected by several factors which determine two measurable parameters: the natural frequency (f_n) and the damping coefficient (ζ).[2] The purpose of this study was to measure the dynamic response (f_n and ζ) of 3 TTS and to compare simultaneous blood pressure measurements in patients in the intensive care unit (ICU).

Methods. The study was approved by the Institutional human research committee. A three-branched device, 9 inches long (Fig. 1) was assembled to obtain readings of arterial pressure from the 3 TTS simultaneously, as well as from each separately. The 3 TTS used were: 1) P50: Statham P50A transducer attached directly to one of the three branches. 2) P23-6": Statham P23 ID transducer attached to another branch by 6 inches of low compliance tubing. 3) P23-5': Statham P23 ID transducer attached to the third branch by 5 feet of low compliance tubing. Measurement of f_n and ζ was achieved by the input of a square wave and a sine wave of progressively increasing frequency into the 3 TTS. Subjects used for the clinical part of this study were patients in stable state in the ICU. All had arterial cannulae placed for reasons unrelated to this study. The 3-branched device was attached to the arterial cannula and the system was opened to air. Transducers were calibrated and the position adjusted such that all were recording zero mmHg. Simultaneous recordings of pressure waveforms and electronic mean pressure from all 3 TTS were obtained. Recordings of pressures from each of the TTS were obtained individually with the other 2 turned off. Data were analyzed using Student's t-test, correlation coefficient, and regression line analysis.

Results. Dynamic response measurements revealed f_n values of 42 Hz, 33 Hz and 6.45 Hz for P50, P23-6", and P23-5' respectively. All systems were underdamped with ζ between .1 and .3. Sixteen patients were studied twice each. Brachial and radial arteries were used in 8 patients each. There were no differences between systolic pressures obtained in each system separately and when the other two systems were simultaneously recording. Simultaneous systolic pressures obtained from P23-5' were 16.3% higher, on average, than those from P50, $P < 0.001$ (Fig. 2). Systolic pressures obtained from P50 were identical to those obtained from P23-6". The overshoot of systolic pressure with P23-5' was significantly higher ($P < 0.02$) when radial artery was used as compared to when the brachial artery was used. There were no differences in diastolic and mean pressure measurements between the 3 TTS.

Discussion: The fidelity of reproduction of the pressure signal is dependent on the f_n of the recording system and on the frequency content of the signal. As the latter approaches the f_n of the system, progressive amplification of the output signal occurs. The frequency content of the blood pressure signal is 10-20 Hz.[1] The f_n of P50 system was well above the frequency content of the pressure signal and could thus be assumed to record the signal with minimal distortion. On the basis of the results of this study, we conclude that 1) reports of systolic arterial hypertension derived from measurements using long tubings without definition of the f_n of the recording system should be suspect. 2) transducer-tubing systems with f_n of 33 Hz produced identical systolic blood pressure as TTS with higher f_n. 3) documentation of the dynamic response of the equipment used for measurement of arterial pressure signal is imperative if these signals are to be used for clinical decision making or for research purposes.

References.

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2. Gardner RM: Direct blood pressure measurement. Dynamic response requirements. Anesthesiology 54:227-236, 1981
3. Bruner JMR, Krenis LJ, Kunsman JM, et al Comparison of direct and indirect methods of measuring arterial blood pressure. Med Instrumentation 15:11-21, 1981

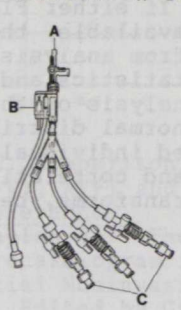

Fig. 1

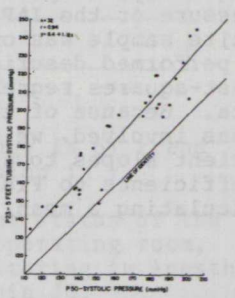

Fig. 2