T400-Series Technical Note

Keys to Measurement Accuracy on a Curved Vessel

Transonic's continuing search to establish accuracy limits has uncovered an unexpected result. Although, in general, the Transonic® Flowprobe is largely insensitive to vessel curvature and vessel-Probe alignment, there is one instance where Flowprobe orientation on a vessel does make a significant difference.

When implanting the Flowprobe on an arched vessel, the investigator normally can choose to place the Probe body in such a way that the path of the ultrasonic plane wave is either perpendicular to or in a plane with the curvature of the vessel. In this case the findings of several experimenters confirm the predictions of vector analysis. While perpendicular placement results in data that approximates true flow (well within the specified accuracy of the Probe), placement of the Probe body within the plane of the curvature can produce flow readings that are appreciably lower than actual flow.

This finding presents no real problem in applications such as the ascending aorta of the dog, where, although curvature is present, the recommended application protocol (via a 3-4 left intercostal thoracotomy) makes the correct orientation and the most convenient orientation coincident. Hartman et al (1985) showed that the Transonic® Flowprobe is extremely accurate when compared with timed exsanguination and with other derivative techniques such as thermal dilution and an electromagnetic system.

However, when a midline sternotomy is chosen for an ascending aorta implant, the investigator should take care to orient the Flowprobe so that its body is perpendicular to the plane of the curvature (Fig. 1). If the Probe were oriented with its body and the plane formed by the V-shaped ultrasonic illumination coinciding, the two flow vectors being measured as the ultrasound crosses and recrosses the vessel during one transmit-receive sequence would both approach zero as the incident angle for each half of the reflective pathway approached the perpendicular (Fig. 3). Depending on the radius of curvature, the measured flow would be lower than the true flow.

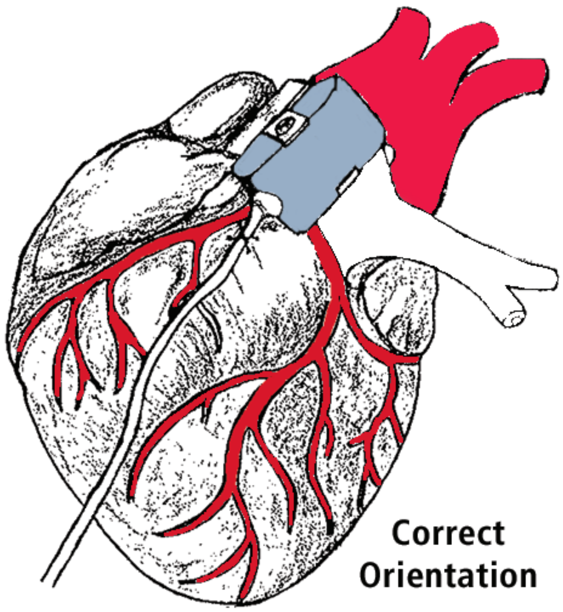

Fig. 1: Diagram of a heart showing orientation of a Flowprobe perpendicular to the vessel being measured.

In extreme cases a few Transonic® users, when Probes have been applied so that the plane defined by the path of the reflective ultrasonic beam and the plane defined by the curvature of the vessel have coincided, have reported flows of approximately half the expected values reported in the literature. In some instances it may not be possible to choose the appropriate orientation for Probe application to an acutely curved vessel. In that case, accurate relative flow data will be produced but cannot be reported in absolute terms unless a calibration is performed and the calibration proves to be linear over the relevant flow ranges. For information on calibrating Perivascular Flowprobes see RL-5-tn.

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Keys to Measurement Accuracy on a Curved Vessel Cont.

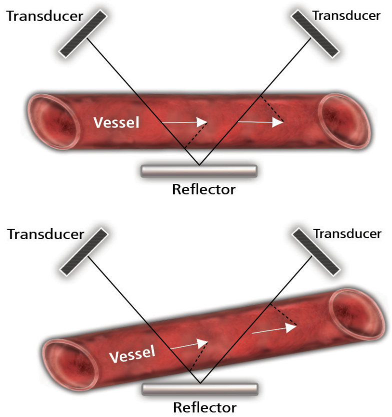

Fig. 2: Using wide beam illumination, two transducers pass ultrasonic signals back and forth, alternately intersecting the flowing liquid in upstream and downstream directions. The Flowmeter derives an accurate measure of the "transit time" it takes for the wave of ultrasound to travel from one transducer to the other. The difference between the upstream and downstream integrated transit times is a measure of volume flow rather than velocity. The ultrasonic beam intersects the vessel twice on its reflective path. With each intersection, the transit time through the vessel is modified by a vector component of flow. The full transit time of the ultrasonic beam senses the sum of these two vector components. With misalignment (bottom), one vector component of flow increases as the other decreases, with little consequence to their sum.

PAU-SERIES PROBES

The best choice for curved vessels 6 mm and larger is using a PAU-Series COnfidence Flowprobe®. The X-beam illumination is insensitive to vessel curvature regardless of orientation (Fig. 4). No additional calibration or special Probe orientation is required to achieve true volume flow measurements within the specified Probe accuracy. Additionally, the PAU Probes are insensitve to turbulence in the flow profile.

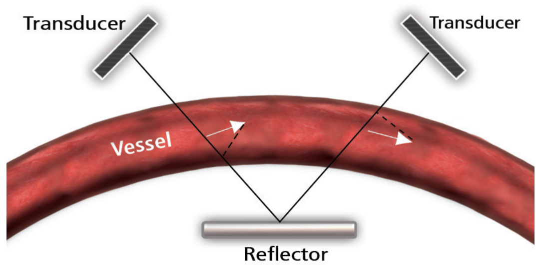

Fig. 3: The worst case of misalignment occurs when the vessel is curved in the plane defined by the path of one ultrasonic wave. In this case, where the angle of transection approaches 90° on each half of the reflective pathway, the Flowmeter underestimates true flow significantly. The problem is corrected when the Probe is placed so that the plane defined by the ultrasonic pathway is perpendicular to the plane defined by the curvature of the vessel.

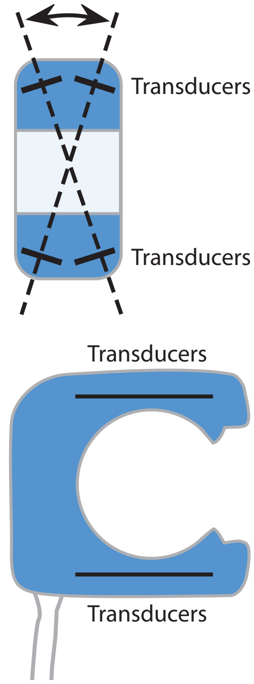

Fig. 4: Four transducers create an X-beam illumination to achieve full vessel volume flow. Each ultrasonic wave only intersects the vessel once making the measurement insensitive to vessel curvature.

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Transonic Systems Inc. is a global manufacturer of innovative biomedical measurement equipment. Founded in 1983, Transonic sells "gold standard" transit-time ultrasound flowmeters and monitors for surgical, hemodialysis, pediatric critical care, perfusion, interventional radiology and research applications. In addition, Transonic provides pressure and pressure volume systems, laser Doppler flowmeters and telemetry systems.

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