Transonic Technical Note #106

Mitral Valve Regurgitation in Sheep

Cardiac Output Pulmonary Artery Flow

Achieving successful results with Transonic flowprobes (either A-Series or older S-Series) on the pulmonary artery (PA) is relatively easy due to the anatomy (see Surgical Protocols #80 and #20). However, a change in flow through the PA does not necessarily indicate mitral valve regurgitation (MVR).

References

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Cardiac Output Pulmonary Artery Flow

Achieving successful results with Transonic flowprobes (either A-Series or older S-Series) on the pulmonary artery (PA) is relatively easy due to the anatomy (see Surgical Protocols #80 and #20). However, a change in flow through the PA does not necessarily indicate mitral valve regurgitation (MVR). other causes. At least one group corroborated regurgitant flow by measuring Total stroke volume (SV) using Sonometrics" crystals (EDV-ESV), and subtracting from it the SV derived from a systemic vessel (i.e. ascending aorta, or main PA (right CO always equals left CO). The subtraction yields the regurgitant volume.

MVR Flow Measurement

MVR has not yet been directly measured with any current (or past) technology or combinations of technologies. Direct MVR measurement cannot be demonstrated by a decrease in cardiac output in the ascending aorta (AA) or an increase in back flow through the left pulmonary veins because these changes could be due an increase in mitral resistance, stenosis, or some other type of interference. Additionally, a decrease in flow through the aorta could be due to regurgitation in any of the four valves.

Ascending Aorta Cardiac Output Measurement

Accessing the ascending aorta in sheep is difficult due to the bifurcation of the aorta exiting the heart. Nevertheless, cardiac output through the ascending aorta in sheep has been measured using our 16SS probe (SP#20)[1,2,3,4] These papers report reasonable results with our older S-series probes although the reported flows are lower than cardiac output expected with the A-series probes (approx. 2.3 L/min)[5]. It is also important to take the coronary flow into account when determining the amount of regurgitation using the ascending aorta. The coronary flow is best seen in a normal ascending aortic waveform as the negative "dip" below baseline or "zero" flow. Aortic valve regurgitation will greatly exaggerate this negative dip although a comparison to a normal (control) animal would probably be necessary to demonstrate the deviation or excess back flow from normal coronary flow.

Cardiac output has been measured with transit-time A-series probes in many species. Currently using A-probes on the sheep ascending aorta is Dr. L. Henry Edmund's group in the Department of Cardiothoracic Surgery at the Univ. of Pennsylvania. This group presented 3 abstracts at the 73rd annual AHA Scientific Sessions in New Orleans[6,7,8] using ECHO but have not yet published their use with the 20A or 24A on 40-80 kg sheep since they only started using the A-probes on the ascending aorta in late 1998. Frederick van der Veen's group (Department of Cardiothoracic Surgery, Cardiovascular Research Institute, Maastricht, Netherlands) has published cardiac output measurements with a 32A probe on the descending aorta of 61-76 kg sheep[9].

Dr. Robin Gleed's lab at Cornell University has implanted small A-series probes on the pulmonary veins within the sheep lung but has not yet published his results[10]. Using older style S-probes, Yellin, Nikolic, and Fratei have measured mitral flow in a dog using a flowprobe around the pulmonary vein and an electromagnetic probe around the mitral orifice[11]. Their paper includes normal waveforms for the pulmonary vein and waveforms indicating mitral regurgitation in coordination with left arterial pressure. Dr. Gleed has noted that making a measurement (and retaining patency) on a pulmonary vein is extremely difficult.

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[14]Millar Instruments, Inc., P.O. Box 230227, Houston, Texas 77223-0227 OR 6001-A Gulf Freeway, Houston, Texas 77023-5417,
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Volume blood flow through either the AA or the pulmonary vein offers important information and other technologies help in providing a complete picture. Sonometrics' Sonomicrometer and ultrasound crystals are used for contractility measurements (i.e. pressure-volume loops) or Cardiodynamics' conductance catheter are used to measure the luminal volume of the chambers of the heart[12,13]. Millar's LV pressure transducer is also useful to determine changes in cardiac output related to changes in blood pressure rather than regurgitation[14]. 3D Echocardiography to monitor flow gives a 3D view of regurgitation on video and is useful to show volumes and wall motion analysis but can not be used to measure flow[15,16].

A real time analysis and data acquisition software package is useful to show real time flow waveforms and pressure-volume (PV) dynamics. The IOX software package from French-based EMKA Technologies or Labview from National Instruments' provides integrated data acquisition software with accompanying real time graphical and statistical analysis[17,18]. Either package provides flow waveforms while continually monitoring LV pressure and deriving PV loops as well as showing the statistics (such as heart rate, stroke volume, etc). Both companies can also provide ECG and are NIST and GLP compliance. The information obtained from using an integrated software system provides a total picture of mitral valve regurgitation.

Summary

Transit-time probes will measure a decrease in cardiac output caused by mitral regurgitation, but they cannot directly differentiate mitral regurgitation from other conditions. An A-series probe on the ascending aorta will quantify the change in stroke volume. Echocardiography can be then used to confirm the presence of reverse flow. It may also be possible, in an acute experiment, to qualitatively evaluate regurgitation by thermodilution via dispersal of the dilution curve by placing a thermodilution sensor in the aorta or left ventricle and injecting a bolus of iced saline through the left atrial wall.