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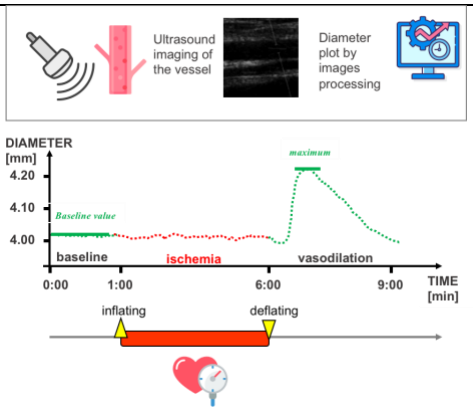
FLOW-MEDIATED DILATION (FMD)

What is it?	In the 1990s, a technique for the assessment of endothelium-dependent Flow-Mediated Vasodilation (FMD) was developed [Celermajer 1992] and guidelines for its assessment from ultrasound imaging in the brachial artery have been well established [Corretti 2002]. The technique induces the release of nitric oxide (NO), resulting in arterial dilation that can provide information about endothelial vasomotor function. More specifically, the procedure requires the subject to be supine, at rest, in a quiet air-conditioned room. Brachial artery longitudinal images are acquired with a linear ultrasound probe above the antecubital fossa. After a baseline measurement (generally 1 min), a sphygmomanometric cuff, placed distal to the analysed vessel, is inflated to suprasystolic pressure, occluding arterial blood flow. Occlusion is maintained for 5 minutes, after which the cuff is deflated. The subsequent reactive hyperemia leads to an increase in shear stress stimulus, which in turn induces the endothelium to release NO, a vasodilator. FMD is quantified as the percentage change in diameter from the baseline to the maximum value obtained after cuff deflation. The brachial artery should be imaged for at least 3 minutes after deflation.
Why do we measure it?	FMD approach is based on the assessment of an endothelium-dependent response to an increased blood flow and the resulting increase in shear stress (see **Endothelium)**. FMD is related to coronary artery endothelial function and cardiovascular risk factors; it is an independent predictor of cardiovascular disease outcome [Thijssen 2019].
How can it be measured?	FMD can be measured with ultrasound by using linear array probes with frequencies ranging 7.5-12 MHz are usually adopted for imaging acquisition. Automated and semi-automated systems processing the ultrasound data have been developed [Thijssen 2019]. These systems can be based for example on wall tracking algorithm that, by processing the image sequences, can provide reliable diameter assessment throughout the entire examination [Ghiadoni 2012]. Real-time approach is preferable above an offline processing approach, due to the immediate feedback provided to the operator. A probe holder is highly recommended in order to maintain the position of the ultrasound probe during the examination [Thijssen 2019]. Pulsed Doppler velocity signal obtained from a midartery sample volume can be used to verify and quantify the shear rate stimulus provoking the vessel reaction.

Where is it measured?	FMD is typically measured at brachial artery (typical diameter 3–5mm). The same approach can also be performed at the radial, superficial femoral or popliteal arteries [Thijssen 2019].
Figure	 Flow-Mediated Dilation timeline and example of a related diameter plot. After a baseline measurement, the arterial flow is occluded for 5 minutes by a cuff. When the cuff is deflated, the subsequent reactive hyperemia provokes an increase in shear stress stimulus that induces, in a healthy vessel, a vasodilation. Diameter values are obtained by processing of longitudinal ultrasound scans of the vessel (top).
References	Celermajer, 1992. DOI: 10.1016/0140-6736(92)93147-f Coretti, 2002. DOI: 10.1016/s0735-1097(01)01746-6 Thijssen 2019. DOI: 10.1093/eurheartj/ehz350 Ghiadoni 2012. DOI: 10.1097/HJH.0b013e328353f222

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