

# Intracardiac welding – a hot technology?

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Patent foramen ovale is a common finding and has been shown to be a potential doorway for thromboembolic lesions of the brain originating from the venous system. Occasionally such material, which usually ends up in the pulmonary circulation [1], has been caught in the act of passing through a patent foramen ovale [2]. Considering the functional consequences of stroke, the recent attempts to close potential doors in symptomatic patients [3] with devices that also have other potential applications [4] are logical steps forward. However, technical difficulties (fig. 1) and the life-long presence of foreign material within the cardiac cavities which may induce device-specific complications in the short and long run (thrombus buildup, infection, arrhythmia, migration, erosion, fracture, etc) provide the setting for the current keen interest in device-less alternatives.

Various technologies have been developed for implant-less interventions within the heart without stopping it. This includes off-pump cardiac repair (OPCARE), allowing intra-cardiac tailoring and suturing with robotic assistance in the experimental setting [5, 6]. These and other studies have shown that there are two main issues for successful working-heart intracardiac repair, namely visualisation and instrumentation. Although application of thermal energy is well established for the creation of lesion patterns, eg in the treatment of atrial fibrillation. This approach has not so far been used to weld mobile cardiac structures. In

contrast, cryotherapy has been proposed not only for ablation of conducting tissue but also for temporary sealing of cardiac perforations [7].

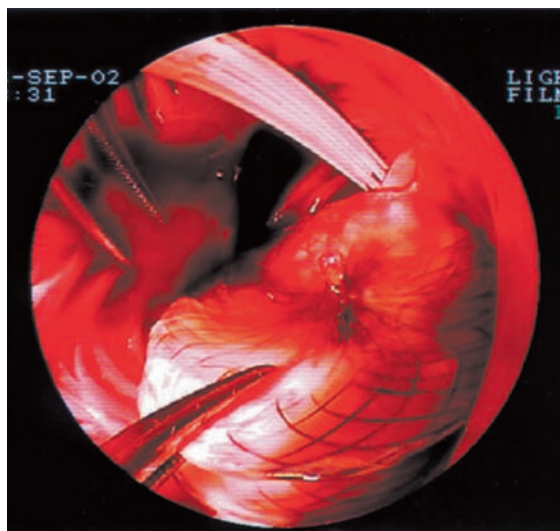
Initial clinical data on device-less closure (welding) of atrial communications is reported by Walpoth et al. in this issue [8]. For this purpose, radiofrequency is applied to the two overlapping borders of the patent foramen ovale which are held together by a vacuum driven suction cup in transcatheter fashion. The bonding mechanism used in this setting is based on protein denaturation by locally applied thermal energy (radiofrequency). Although the preliminary results reported are not a total success story, and the authors admit that there is a learning curve, the technique described has major potential for the applications presented and others. It may however be useful to recall some basic facts drawn from industrial welding technologies.

Welding of metals, for example, is an extremely sophisticated process requiring control of many parameters. Welding of two components made of steel is based on melting of both components' surfaces, with or without the use of additional melted material plus anti-oxydants etc. The necessary energy can be brought to the welding site from various sources. Oxyfuel is just one interesting technical option because it can also be used under water. For high output industrial production, however, an electric arc is more frequently used, a technology that is also used in melting scrap in steel mills. A more sophisticated technology is the recent development of laser welding, which in turn can be used to focus energy very precisely and may also have potential for intravascular application, ie in conjunction with a transparent optical carrier such as a water jet.

Spot-welding is the industrial technology which comes closest to the device-less foramen ovale closure presented in this issue. As a matter of fact, industrial spot-welding is not only carried out with localised highly focused energy, but is also known to require close approximation of the two metal or plastic parts needing to be joined. This industrial reality is related to the fact that no additional melted material is added, and may explain why the reported clinical application of this concept through temporary suction for position-

**Figure 1**

Endoscopic view of a displaced atrial septal occluder (Amplatzer) with both lips in the right atrium (bottom) during surgical removal through a right mini-thoracotomy with subsequent suture repair.



ing has not always been successful. The weakness of the reported device-less closure of the foramen ovale may indeed be lack of approximation, which in turn may be the result of inadequate visualisation [6]. It can be expected that improved and proven approximation (eg by 4D-echocardiography) of the overlapping borders of the foramen ovale prior to energy application will also yield better outcomes for this and other clinical welding procedures.

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