Surgical occlusion of the left atrial appendage: it is time to adopt newer techniques!

Background and rationale

Atrial fibrillation (AF), the most common sustained cardiac arrhythmia with a steadily increasing prevalence worldwide, is associated with substantial morbidity and mortality due to subsequent thrombo-embolic stroke.1 For decades, oral anticoagulation (OAC) with vitamin K antagonists (VKAs) remained the mainstay of stroke prevention therapies. The recent development and introduction of newer non-vitamin K-dependent oral anticoagulants (NOACs) have yielded superior safety and efficacy profiles, thus becoming the new gold standard of anticoagulation treatment.2–4

However, due to the inherent risk of bleeding complications with antithrombotic therapies, the search for alternative stroke reduction/prevention strategies have not been abandoned. In fact, in 1947 Hellerstein promoted antithrombotic therapies, the search for alternative stroke reduction/prevention strategies have not been abandoned. In fact, in 1947 Hellerstein demonstrated in a canine model exclusion of the left atrial appendage (LAA) by means of a LAA resection as an alternative approach.5

In his seminal report, Madden later published his first two cases of LAA resection in humans.6 Following, concomitant LAA exclusion by various surgical techniques carved out a niche existence for decades during high-risk mitral valve procedures until it again became popular in the mid-1980s when James Cox introduced a surgical treatment of AF with the Cox-maze procedure incorporating resection of the LAA.7 However, the failure of different surgical techniques to achieve complete closure of the LAA and the introduction and subsequent experience of percutaneous LAA occlusion devices for stroke prevention risk reduction remained an important issue.8 As a consequence, newer promising surgical techniques have evolved over the past decade.

Surgical techniques for left atrial appendage exclusion: the devil is in the detail!

Currently, various surgical techniques for LAA exclusion are available and may be best categorized by endocardial or epicardial and device-enabled or non-device-enabled approaches (Figure 1).8–11

Endocardial approaches

Incorporate over sewing the os of the LAA by opening the left atrium (LA) and using:

- Teflon felt-pledged reinforced purse-string sutures,
- by running and/or mattress sutures,
- or by a combination of these techniques with the LAA first invaginated into the LA and pulled out after placement of a purse-string suture.

Epicardial approaches

The cut-and-sew method, also referred to as left atrial appendectomy, as first described by Hellerstein and Madden, incorporates resection of the LAA from the epicardial surface and over sewing of the LAA base.5,6

With the simple suture ligation technique, exclusion of the LAA is achieved by placement of a ligature at the base of the LAA from the epicardial aspect.

Device-enabled techniques

The first device-enabled techniques consisted of using non-dedicated cutting or non-cutting surgical stapler devices to exclude the LAA epicardially (e.g. Endo GIA II, Medtronic, Minneapolis, MN, USA or EZ45, Ethicon Inc., Cincinnati, OH, USA).12,13

Other epicardial LAA exclusion devices such as the Endoloop snaring device (ligation by a detachable snare loop at the base of the LAA) and the LigaSure vessel-sealing system (tissue welding of the LAA base by radiofrequency energy) only gained marginal attention in the cardiothoracic community for surgical LAA closure.14,15

Almost a decade ago, the AtriClip (AtriCure, Inc., West Chester, OH, USA) LAA exclusion system (a titanium clip formed by two parallel tubes applying uniform, dynamic pressure) was introduced into clinical practice and has been sold and utilized in over 100 000 cases of concomitant or stand-alone epicardial device-enabled LAA exclusion procedures worldwide.16

Another device-enabled epicardial LAA exclusion device, the TigerPaw system (implantable soft silicone fastener), was withdrawn from the market in 2015 for safety concerns and is expected to be relaunched soon with a revised next-generation version.17

Current evidence of surgical left atrial appendage

The goal of LAA exclusion is to attain a smooth endocardial surface with the LAA permanently excluded from systemic circulation. Due to the complex nature and variable anatomy of the LAA, most of the surgical techniques failed to reliably and completely occlude the LAA.18 Residual gaps and subsequent flow between the LA and LAA resulted after various types of endocardial and epicardial approaches (namely any endocardial approach and simple epicardial suture ligation).

In a landmark transoesophageal (TOE) study in 137 patients, Kanderian et al. showed a success rate of only 40% (55/137) after surgical LAA closure.11 A meta-analysis conducted by Dawson et al. demonstrated comparable low success rates (55–66%) in achieving complete LAA occlusion.19 In line with these findings, the first randomized clinical trial in surgical LAA closure was prematurely discontinued due to high failure rates to achieve complete closure.20

While LAA resection/amputation and the use of cutting or non-cutting surgical stapler devices seem to offer higher success rates in closure of the LAA, these techniques come along with higher rates of residual stump formation (>10 mm).8,11 Further, the utilization of...
stapler devices on the fragile LAA tissue is associated with an increased risk for bleeding complications from the suture line.

In contrast, short- and long-term follow-up (FU) data from the experience with the AtriClip device seems to suggest a potential efficacy in stroke prevention/risk reduction in patients undergoing cardiac surgery. The most recent long-term follow-up of 291 consecutive patients demonstrated complete closure of the LAA without any safety events. Moreover, computed tomography (CT) imaging data (up to 8 years of FU) showed excellent durability of the device with the absence of any significant residual stump formation or re-communication of the LA with the LAA. In a subgroup analysis of patients taken off from any antithrombotic regimen, a relative risk reduction of 87.5% for stroke risk according to their CHA2DS2-VASc-score was achieved.

**Controversies, current challenges, and outlook**

In contrast to percutaneous LAA occlusion devices, a major issue of surgical LAA occlusion techniques remains, the lack of robust clinical data derived from properly conducted randomized clinical trials. Most of the surgical data are limited to smaller registries, observational cohort studies or case series, or single centre experiences with available data being mostly inconclusive and with conflicting results.

As a consequence, the 2016 European Society of Cardiology (ESC) Guidelines for the management of AF developed in collaboration with the European Association for Cardiothoracic Surgery (EACTS) only gives a Class IIb, Level of Evidence B recommendation to consider surgical occlusion or exclusion during concomitant cardiac surgery in patients with AF, while the most recent Society of Thoracic Surgeons 2017 Clinical Practice Guidelines for the Surgical Treatment of Atrial Fibrillation issues a Class IIa, Level C expert opinion recommendation, both without further substantiating the method of the technique. Furthermore, the current guidelines continue to recommend antithrombotic therapy after LAA closure, thereby still keeping the patient at risk for associated bleeding complications.

The ultimate goal of LAA management should be to eliminate the predilection site for thrombus formation within the LAA thus alleviating/relieving the patient from anticoagulation associated bleeding risks. It is to be investigated whether a continued anticoagulation regimen in addition to LAA closure, adds any significant benefit to stroke risk reduction. At least, the experiences from the Watchman devices seem to contradict this assumption. However, in light of the uncertainties of surgical LAA occlusion with the continued incorporation of obsole-lete techniques, a recommendation for anticoagulation therapy is currently still justified.

To achieve the goal of complete occlusion it must be ensured that reperfusion of the LAA through gaps or re-connections and significant residual stumps (>1 cm) do not occur—not only intra-procedurally and in the short-term, but also at long-term FU, since these conditions are well proven to significantly increase the risk of thrombo-embolic events by enhanced thrombogenicity.

A large, first of its kind randomized surgical controlled trial, assessing concomitant LAA closure in patients with AF who are undergoing cardiac surgery is currently enrolling patients to deliver the long needed robust data for surgical LAA closure. However, several methodological issues do remain: the mode of LAA closure is left to the discretion...
of the surgeon with the potential risk of incorporating outdated surgical techniques and importantly, OAC is further recommended after LAA closure. Hence, interpretation of the results in regard to stroke prevention/risk reduction may be challenging under these circumstances.

Despite the heterogenicity of present surgical data, a recent retrospective cohort study with a considerable amount of propensity matched patients revealed concurrent surgical LAA closure to be associated with reduced risk of stroke and all-cause mortality compared to patients without LAA closure.26 The experiences from the percutaneous devices seem to be in line with these findings.38

The definition of the stump length currently defined as safe <10 mm in the surgical setting, remains controversial and needs further investigation.11,20,24,27 Further, the unknown clinical relevance of peri-device-flow in percutaneously closed LAAs, together with the associated non-negligible mortality in the real-world setting necessitates a patient-tailored and outcome-oriented strategy, in a true heart-team setting as proven in other programs.

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References
References are available as supplementary material at European Heart Journal online.

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Heart Foundation series

The Swiss Heart Foundation

Short history of the Swiss Heart Foundation: The Swiss Cardiology Foundation, as the heart foundation called itself at the time, was founded on 26 January 1967 in Berne on the initiative of two professors from Western Switzerland, Professor Pierre W. Duchosal (Geneva) and Professor Jean-Louis Rivier (Lausanne). The reason and trigger were a rapid increase in the diagnosis of cardiovascular disease in Switzerland as well as abroad, that was over and above the rate due to increasing age. Right from the start, the Swiss Heart Foundation depended exclusively on private donations, legacies, and sponsoring contributions in order to finance its projects. Since the beginning, the main purpose of the foundation has been to fund cardiovascular research. As the result of a review of the statutes in 1978, this purpose was then extended: patient information, raising public awareness, prevention, and health promotion have become important additional tasks of the foundation. In 1999, the previous cardiological focus of the foundation was extended to include the circulatory (cardiovascular) system as a whole, thereby also including stroke.

Since November 2016, the head office of the Swiss Heart Foundation has been based at the ‘Herzhaus’ (Heart House) in the centre of the federal capital of Berne. It shares these premises with the secretariat of the Swiss Society of Cardiology, the Swiss Society of Hypertension, the Swiss Association of Physicians with surgical and invasive activity and the Swiss Society for Public Health Specialists. Expertise at both therapy and prevention level are hence pooled at the ‘Herzhaus’. The activity of the Swiss Heart Foundation is based on three pillars:

Research funding

The Swiss Heart Foundation occupies a key role. In Switzerland, it is the organization that can provide timely seed funding for cardiovascular research projects. Thus, necessary funds are available during the crucial phase and can facilitate the breakthrough of a good project. As a result, important therapeutic advances have been implemented time and again since the founding days of the foundation; for example, balloon dilatation of the coronary vessels in 1977 by Andreas Grünzig at the Canton Hospital of Zurich and coronary stenting in 1986 by Ulrich Sigwart at the Vaud University Hospital Centre (CHUV) in Lausanne. Moreover, treatment of arteriosclerotic cardiovascular diseases has been significantly improved by new drugs. Furthermore, since 1981, an annual research prize is awarded for the best Swiss publication in cardiovascular or stroke research.

Prevention: assuming individual responsibility

Reduction of all cardiovascular risk factors is a key concern of the foundation. Its programmes include the life-saving programme ‘HELP’ and various services offered within the framework of workplace health