Feasibility, safety, and outcome of a challenging transseptal puncture facilitated by radiofrequency energy delivery: a prospective single-centre study

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Aims
Although it has been shown that a transseptal (TS) puncture in the electrophysiology laboratory is associated with a high success and a low complication rate, this procedure remains challenging particularly in difficult septum anatomies (aneurismal septum and thick septum) and during repeat TS catheterization. Radiofrequency (RF) electrocautery current delivery through the TS needle has been shown to facilitate the TS puncture. The aim of this study was to verify prospectively the feasibility, safety, and outcome of RF energy delivery associated with the standard TS technique in patients undergoing a challenging TS puncture.

Methods and results
Over a 14-month period, 162 consecutive patients underwent left atrial (LA) arrhythmia ablation in our centre. Among them, we enrolled 18 patients who failed LA access after two TS puncture attempts. In these patients, an RF delivery through TS (RF-TS) needle approach was used to reach the LA. All 18 patients had a successful RF-TS at the first attempt. A transoesophageal echocardiography (TEE) guidance and fluoroscopy views were used in all patients. No acute complications were reported. There have been no clinical sequelae after 10±4 months of follow-up following the RF-TS approach. Challenging TS punctures were more frequent in repeat LA catheterization when compared with the first LA catheterization, respectively, in 35% (13 of 37) and 4% (5 of 125) of the patients.

Conclusion
Radiofrequency electrocautery delivery associated with the standard TS approach is a safe and reproducible technique to reach the left atrium, using the TEE guidance. This technique is helpful during repeat TS catheterization and in the presence of anatomical atrial septum abnormalities.

Keywords
Transseptal puncture • Atrial fibrillation • Ablation • Radiofrequency • Atrial septum

Introduction
Puncture of the atrial septum was initially performed to access the left atrium for diagnostic purposes. The techniques used have changed very little since the initial description in 1959.1,2 The standard and accepted approach consists of the puncture of the fossa ovalis with a specifically designed needle under single or biplane fluoroscopy guided by one or both of the following: anatomical landmarks (catheter in the ascending aorta, catheter in the coronary sinus, catheter in the His bundle, radiocontrast injection, and staining of the atrial septum)1–3 and image guidance (transoesophageal or intracardiac echocardiographic (ICE) imaging).4,5 Although it has been shown that septal puncture in the electrophysiology laboratory is associated with a high success and a low complication rate,6 this procedure still remains challenging in inexperienced hands, in difficult septum anatomies (aneurismal septum, thick septum), or during repeat punctures after a previous AF ablation.6–8 A substantial number of patients require a second left atrial (LA) procedure after ablation for AF, either for LA flutter, atrial tachycardia, or recurrent AF. Compared with the first procedure, the repeat transseptal (TS) catheterization after the ablation for AF might be more challenging and potentially associated with more complications.9

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New techniques and technologies have been developed in order to simplify TS puncture and to increase the safety of this procedure, particularly in complex cases. Among them, the use of radiofrequency energy to cross the septum has been reported. We prospectively used this technique in a population of patients where TS catheterization was needed but failed after two standard TS puncture attempts.

**Methods**

**Study population**

Over a 14-month period, 162 consecutive patients required TS puncture for an LA procedure in our centre. One hundred and twenty-five patients underwent first LA procedure and 37 patients repeated LA procedure. We enrolled 18 (11%) patients who failed LA access after two TS puncture attempts performed by a skilled operator. In these patients, after two TS attempts, an RF delivery through TS (RF-TS) needle approach was used to reach the LA. All patients provided informed consent to the procedure. To exclude the presence of thrombi in the LA appendage, all patients underwent two-dimensional (2D) transthoracic echocardiography (TTE) the day before the procedure, along with a transthoracic examination (TEE) enabling assessment of LA dimensions, left ventricle, and valvular function.

**Transseptal technique (standard approach)**

Ablation was performed under general anaesthesia. A 6 F pigtail catheter just superior to the aortic valve or a 6 F quadripolar diagnostic catheter in the His bundle was used in all cases. A 6 F quadripolar catheter was inserted in the right jugular vein and advanced in the coronary sinus. Two- or three-dimensional TEE guidance was used in all procedures. The TS sheath and dilator were advanced into the superior vena cava over a guidewire via the femoral vein. After removing the guidewire and aspirating and flushing the dilator, the Brockenbrough needle was inserted in the dilator. After that, the sheath/dilator/needle assembly were slowly withdrawn together while monitoring mono- or biplane fluoroscopy. Under fluoroscopic guidance (antero-posterior projection), during gradual sheath/dilator/needle withdrawal oriented between the 4 and 6 o’clock handle position, the fossa ovalis was engaged, indicated by a sudden displacement of the sheath tip and/or tenting of the septum on TEE. Contrast was injected through the needle to confirm a septal location. Left atrial access was obtained by passing the needle extended through the dilator. Once the needle was removed, the guidewire was advanced in the left superior pulmonary vein (PV). The sheath was advanced over the dilator and positioned in the left atrium, after which the dilator was removed. After gaining LA access, a 70 UI/Kg heparin iv bolus was given. Activated clotting time was maintained around 250 s during the procedure.

**Transseptal technique (radiofrequency approach)**

When LA access could not be achieved after two attempts, RF energy was applied directly to the proximal part of the needle in order to pass the interatrial septum (RF-TS puncture). This technique has been exhaustively and recently described. Briefly, the first part of TS puncture technique had no variation. Once correct positioning in the fossa ovalis of the sheath/needle assembly was confirmed using fluoroscopy and TEE, the needle was advanced almost to the tip of the dilator without exposing the needle beyond the dilator. At this point, a standard unipolar cautery pen (Valleylab, Force 2, Bloomfield, CT, USA; Figure 1A) was then applied to the proximal portion of the Brockenbrough needle (Figure 1B), and 1–2 s pulse of cut-mode cautery was applied to the needle as its tip was advanced out of the dilator. The electrosurgical cautery was set at 15 W. To note, conversely to previous groups, we used a TEE guidance instead of ICE and we always gave heparin only after gaining the LA access. Radiofrequency delivery through TS puncture was never applied twice in the same patient. Whether a second TS access was used or not, a 0.032 in. exchange length guidewire was passed through the hole previously obtained, anchored in one of the branches of the left superior PV, and used as support and guide to insert the second TS sheath.

**Ablation procedure**

All but three procedures were performed using a 3D electroanatomic mapping system (Carto, Biosense Webster). In patients with paroxysmal AF, a circular lesion was placed around the ostia of the PVs. In patients with persistent AF, LA tachycardia/flutter, and paroxysmal AF with documented PVs reconnection, additional LA linear lesions or complex-fractionated atrial electrogram ablation was performed. Radiofrequency ablation was delivered using a 3.5 mm irrigated tip.
catheter (Navistar Thermocool, Johnson and Johnson) in a temperature-guide fashion with a pre-selected temperature of 45°C and a maximum power of 35 W. Power application was limited to 20 W in the LA posterior wall. Patients 2, 14, and 15, all with paroxysmal AF, underwent a cryoballoon ablation (ArctiFront, Medtronic). The cryoballoon ablation technique has been described previously.13 In these three patients, a 28 mm diameter balloon was used passing through a 15 F sheath. Cryoenergy was applied for 5 min per application for two times in each vein, resulting in a circumferential ablation lesion. Pulmonary vein electrical isolation was verified after cryoenergy application with a decapolar circumferential mapping catheter (Lasso, Biosense Webster, Diamond Bar, CA, USA).

Statistical analysis
Results are presented as means ± SD. Categorical variables are expressed as percentages.

Result
Study population
From 162 patients undergoing LA ablation procedures, a total of 18 (11%) patients required an RF-TS puncture approach (5 females, age 58.7 ± 7.9 years) because of failure to reach the LA after two TS puncture attempts using the standard approach. Of the 162 patients, 37 had already undergone at least one previous LA ablation with TS puncture and 16 presented interatrial septal abnormalities at the TEE. Baseline characteristics of the study population are summarized in Table 1. Twelve patients underwent a repeat LA access for LA arrhythmias, four patients had interatrial structural abnormalities (Figure 2), one patient had an apparently normal interatrial septum, and one patient, undergoing a repeat LA access, presented a thick interatrial septum. The average of previous LA catheterization was 1.7 (1–3). Twelve patients had paroxysmal AF, four patients had persistent AF, and two patients had LA flutter. Left ventricular ejection fraction was 62.1 ± 5.7% and the LA diameter was 43 ± 3.5 mm.

Transseptal with the radiofrequency approach
All 18 patients had a successful TS puncture with the RF delivery at the first attempt. One patient required two electrocautery applications. This happened at the very beginning (Patient 2) of our experience with RF-TS puncture. No charring was noted to the distal aspect of the TS sheath following removal at the end of the procedure. Transoesophageal echocardiographic guidance and fluoroscopy views were used in all patients. No acute complications were reported. There have been no clinical sequelae at a follow-up of 10 ± 4 months following the RF-TS approach.

Discussion
Radiofrequency current delivery to the fossa ovalis through the TS needle, in the presence or absence of manifest atrial septum abnormalities, facilitated TS puncture in patients with difficult standard puncture.
Radiofrequency delivery through TS puncture reduces the pressure required on the TS needle as it crosses the septum and has demonstrated, under TEE guidance, to be very safe in this cohort of patients. In all patients, TS access was obtained at the first attempt with RF. One patient required a second RF application. A second RF application was probably necessary due to the fact that we missed the synchronization between the instant in which RF application was applied to the hub of the needle (second operator) and the concomitant slight movement towards the septum of the needle (first operator). We have to underline that in this case, the position of the sheath and the needle did not change between one application and the other. No complications occurred during any RF-TS puncture in our series.

Our study confirms that challenging TS punctures are more frequent in repeat LA catheterization. Comparing the first LA access with the repeat LA access, a challenging RF-TS puncture occurred, respectively, in 4% (5 of 125) and 35% (13 of 37) of the patients. The latter confirm a trend already reported by other authors. It is well known that, despite a quite high success rate of AF ablation, a repeat procedure, and therefore TS puncture, is necessary. Repeat TS puncture has shown to be more challenging than the first TS access. Crossing the atrial septum may be more difficult because of different anatomy or increased septal thickness or fibrosis caused by the previous puncture. Marcus et al. reported 16 patients undergoing a repeat TS catheterization. Compared with the first procedure, the repeat TS catheterization after the ablation for AF was more difficult and potentially associated with more complications. Tomlinson et al. had similar results. They reported that repeat TS access was characterized by a trend towards greater difficulty. Moreover, they found a slight, but significant, increase in interatrial septum thickness at the fossa ovalis following catheter ablation of AF. Another group had the same experience in the repeat procedures, but they did not find any difference in septum thickness between the first and the subsequent LA accesses. They reported that the only parameter associated with stiff septum and failed TS puncture was the total number of the previous TS catheterizations. Our experience goes in the same direction: repeat procedure seems to be the main factor responsible for difficult TS puncture in the absence of macroscopic structural abnormalities in the interatrial septum. An explanation might be furnished by a recent study by Hu et al. showing that the puncture site moves higher in the second procedure. They have hypothesized that in repeat LA procedure, the TS needle might tend to shift upwards jumping over the scar created by the previous TS puncture. Another speculative explanation for difficult TS puncture in repeat LA access might be a distorted geometry of the septum and/or of the left atrium after the previous ablation.

Although challenging TS punctures accounted only for 4% (5 of 125 patients) in our series among patients who underwent first LA catheterization, it is well known that TS puncture might be related to life-threatening complications. The risk of the latter is increased if excessive pressure is applied to the needle when tenting the fossa ovalis. Excessive force could result in perforation of the LA posterior wall or damage of the surrounding structures. The great elastic energy accumulated from the sheath/needle assembly while tenting a stiff fossa ovalis might result in a big and involuntary jump against the LA posterior wall. This is especially true in the presence of a mobile or aneurismal fossa ovalis which tent(s) far into the LA cavity.

In an attempt to improve and facilitate the TS puncture, different systems have been developed. Recently, a new nitinol J shape guidewire (Safe Sept, Pressure Products, Inc., USA) has to be shown particularly easy and safe to use. Transseptal puncture with Safe Sept is facilitated thanks to its sharp specially designed tip. Among the others, RF application to the septum has been demonstrated to be feasible. Radiofrequency can be delivered in different ways. A special device (Radiofrequency Transseptal System, Baylis, Medical, Montreal, Canada) has been developed. Instead of a needle, an RF catheter is introduced into the dilator and sheath assembly. Although results seem to be comparable, this system has the disadvantage of being a single-use catheter and not usable for the ablation procedure. Knecht et al. recently reported their experience using RF in 12 patients with difficult or failed LA access. They leded RF current to the atrial septum using the distal part of a standard 3.5 mm irrigated-tip ablation catheter delivering RF energy to the proximal part of the needle. They argued in favour of RF energy delivery using the ablation catheter,
because the electrocautery device might be not available in every lab. On the other hand, electrocautery RF delivery has the advantage of being ablation technique-independent. In our series, three patients underwent cryoballoon ablation. In this case, the use of an RF ablation catheter would have increased the costs of the procedure.

When the RF-TS approach is utilized to facilitate the access to the LA, echocardiographic image guidance is mandatory to avoid potentially serious damage to the surrounding structures such as the aorta. Two previous groups have described the present technique in the general population.11,12 In these studies, the authors utilized ICE guidance as support. In our study, a TEE was used instead of ICE. We believe that it is an important point to discuss because ICE requires a not negligible learning curve to be used, is not available in every laboratory, and is expensive. Contrary to these previous reports, we administered heparin only after gaining the left atrium, as we usually do in all procedures. We had no thrombo-embolic complications.

An important point to be discussed is the acute and the residual damage at the fossa ovalis after which RF energy is delivered. There have been no clinical sequelae at follow-up of 10 ± 4 months following the RF-TS approach. We performed a TTE using a saline contrast after 7 ± 3 months in all patients, and no macroscopic atrial septal defect were identified. Unfortunately, at this moment, none of these patients underwent a repeat TEE after RF-TS.

The only study present in the literature17 comparing the tissue lesions at the level of the fossa ovalis, based on pig models, showed no substantial differences between mechanical TS puncture and RF-TS puncture: the biggest scar was present after 1 month in pigs that underwent RF-TS puncture. Further and more extensive studies are needed in humans to better clarify the residual damage after TS puncture facilitated by RF energy.

**Limitations**

In this study, the definition of ‘challenging’ TS puncture was subjective. This might have increased the prevalence of ‘challenging’ TS punctures in the population of patients enrolled in the study. Moreover, the choice to use only the standard BRK-1 needle in the setting of TS puncture could have limited significantly the direct access into the LA since it has been shown to be not the sharpest one for TS puncture. We defined a TS puncture ‘challenging’ when more than two TS attempts were needed to cross the interatrial septum. The majority of the previous authors described the use of RF associated with TS puncture only after several failed TS puncture attempts. Conversely, we decided to use the RF source only after two TS attempts, performed by a skill operator for two main reasons. We intended to reduce unnecessary and potentially dangerous TS puncture attempts and catheters manipulation. We were sure that difficulties for sheath/needle assembly to pass through the fossa ovalis were related to anatomical aspects (manifest or not) of the atrial septum and/or of the left atrium and not of a wrong position of the sheath/needle assembly against the fossa ovalis, thanks to the presence of the TEE guidance.

Another important limitation of this study is that no TEE has been performed in the follow-up in patients who underwent an RF-TS approach. The important issue of permanence and size of the TS puncture after RF-TS approach should be better investigated. Although our clinical follow-up was free from any kind of complications after several months, it will be really important in the future to describe residual damage at the fossa ovalis after RF delivery with TEE.

**Conclusions**

Radiofrequency electrocautery delivery associated with the standard TS approach is a safe and reproducible technique to reach the LA when performed during direct visualization of the interatrial septum by the TEE guidance.

This technique reduces the pressure required on the TS assembly in order to gain the LA, avoiding unpredictable movements of the needle, and decreasing the numbers of TS attempts and consequently the risk of potential complications. This technique might be helpful especially during repeat catheterization and, less frequently, in the presence of anatomical atrial septum abnormalities.

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**References**


