Very High Power Very Short Duration Ablation for Atrial Fibrillation: with great power comes great responsibility

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February 28, 2022

Abstract

vHPvSD ablation represents a quantum leap from the RF settings that have traditionally been used in electrophysiology. If used to its full potential, it may improve procedural efficiency by reducing ablation and procedure times. However, with great power comes great responsibility; we need to ensure that we use it judiciously and safely.

EDITORIAL

Very High Power Very Short Duration Ablation for Atrial Fibrillation: with great power comes great responsibility

Short Title: Very high power short duration ablation

Key words: HPSD ablation, 90 watts ablation, QDot, QMode

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Word count: 1562

Funding: None

Conflicts of Interest: DG has received research funding from Biosense Webster, Boston Scientific and Medtronic.

For all the advances in electrophysiology, the need to create a focal ablation lesion using radiofrequency (RF) energy has remained remarkably constant. However, the recipe for the perfect RF lesion continues to elude us even after almost 40 years of research and clinical experience. As we continue our search for the holy grail of transmurality and durability with assured safety, there has been renewed interest in temperature controlled (TC) ablation. Accurate tip temperature feedback from catheters such as the QDot Micro^{TM} catheter (Biosense Webster Inc, Irwindale, CA) have allowed for the first time the use of very high power, very short duration (vHPvSD) ablation that utilises 90W RF power for just 4 seconds of ablation per lesion, delivered in the TC mode. Ex-vivo experiments have demonstrated that vHPvSD ablation produces larger, shallower, and more homogeneous lesions as compared to standard power-controlled ablation (sRF); characteristics that should be ideal for the thin-walled left atrial tissue. vHPvSD also produces more transmural and contiguous linear lesions with fewer steam pops compared to sRF ablation, which would be particularly useful for ventricular tissue. If these extremely encouraging results could be replicated in the clinical arena, our search for perfect RF lesion creation may be finally over. Are these high hopes being realised?

The clinical feasibility of the vHPvSD approach was first demonstrated in the QDOT-FAST trial, in which 52 patients underwent successful pulmonary vein isolation (PVI) with impressively short mean procedural and ablation times of 105 min and 8 min respectively. However, new asymptomatic cerebral lesions (ACLs) were identified in 6 (14%) patients who underwent MRI scanning, with 4 of these occurring despite uninterrupted anticoagulation. While no patients suffered clinically significant neurological effects, and all but one of these ACLs resolved on repeat MRI performed at 1 month, it did throw a spotlight on an issue that needed redressal before this technology could supplant the other well-established RF ablation techniques.

In this edition of the Journal of Cardiovascular Electrophysiology, Mueller and colleagues present a single-centre experience of safety outcomes in 34 patients undergoing vHPvSD AF ablation. The principal findings of this study are: 1) modest acute efficacy, as seen by disappointing first pass isolation (FPI) rates of 18% of patients and 54% of PV pairs; 2) a concerning safety signal in the form of coagulum on the catheter tip in 10 (18%) patients and ACLs on post-procedure MRI in 26% patients. The same group had described a similarly high rate of catheter tip coagulum (11%) and ACLs (24%) in a previous cohort of patients after which several software amendments to the RF generator (nGEN) were made. However, it appears that the underlying issue persists. Whilst Mueller and colleagues deserve credit for sharing their findings, these will cause consternation amongst the electrophysiology community. After all, with vHPvSD we were hoping for an improvement in both procedural efficacy and safety, but the data from Mueller *et al.* suggest the polar opposite. This editorial piece will attempt to put these new findings in context with other published work in this area, and also with our own observations gleaned from using vHPvSD for the past 18 months.

Efficacy of vHPvSD Ablation

FPI is an excellent acute indicator of the quality of RF PVI, and it serves as a reliable surrogate for long term success rates. As such it is notable that the reported FPI rates with vHPvSD have been modest, ranging from 18-61% (Table 1). Rates of early PV reconnection during the waiting period are also disappointingly high. Both of these result in need for additional RF applications for gap elimination, thereby offsetting one potential benefit of using vHPvSD, namely reduction in procedure and RF times. This is paradoxical – if the bench data demonstrate a better lesion profile, why is this not mirrored in terms of acute clinical efficacy?

A few hypotheses bear consideration. Firstly, bench studies are performed under controlled conditions where stable contact for the full 4 second duration of the RF application is virtually guaranteed. This is far removed from the clinical setting, where a combination of respiratory and cardiac motion means that contact is likely to be intermittent. In fact, it can be argued that catheter stability in vHPvSD is even more critical than with sRF, because even brief loss of contact is substantial, in relative terms. For example, 2 sec loss of contact in a standard 20 sec ablation represents just 10% of the duration, whilst for vHPvSD it presents 50%. To that end, it is possible that the use of full general anaesthesia, with high frequency, low tidal volume ventilation, may improve results with vHPvSD by stabilising catheter contact. Secondly, lesion contiguity is one of the central tenets of the highly successful CLOSE protocol, which in turn relies on accurate placement of automated lesion tags (Visitags). At the moment, vHPvSD is not compatible with the CARTO Visitag software, which

leads to high variability in placement of the auto-tags depending upon the phase of respiration. This can make accurate tracking of inter-tag distance extremely challenging. Upcoming software enhancements should address this issue. Thirdly, the current approach to vHPvSD utilises a uniform setting of 90W/4sec ablation throughout all areas of the ablation circle. It makes no allowance for the well-recognised differences in tissue thickness between the anterior and posterior left atrial regions, unlike the CLOSE protocol that utilises different ablation-index targets for these regions. It may be relevant that the median depth of vHPvSD lesions seen by Takigawa *et al.* was 2.7mm, which may not be adequate to produce transmurality across the thick left atrial appendage ridge in all patients. Some operators, including ourselves, have tried to get around this limitation by clustering lesions closer together on the anterior segments. It may be no coincidence that the one group that reported high efficacy with vHPvSD had targeted an inter-tag distance of 3-4mm on the anterior wall. Perhaps that is what may be needed for vHPvSD in place of the standard 6mm spacing that was validated on entirely different conventional RF settings.

In summary, whilst more data are needed, it looks likely that the efficacy of vHPvSD ablation may be improved by use of general anaesthesia, and by shortening the inter-tag distance, especially on the anterior segments (Figure 1).

Safety of vHPvSD Ablation

It is important to note that all published case series utilising vHPvSD are extremely small, with patients ranging from 28 to 90. Given the relative infrequency of serious complications such as clinical stroke and atrio-oesophageal complications with AF ablation, these studies are grossly underpowered to provide conclusive safety data. As such, we need to look for surrogate markers of complications, such as oesophageal lesions on endoscopy and asymptomatic cerebral lesions (ACLs) on cranial MRIs.

The incidence of post-procedure oesophageal injury is reassuringly low in the 3 studies that have evaluated this systematically with endoscopy (Table 2). In QDOT-FAST, a haemorrhaging ulcer was seen in just 1 of the 52 patients, and healed with medical therapy. The other two studies, comprising 134 patients, showed no evidence of oesophageal injury in any patient. This reassuring observation is in keeping with the findings of the bench studies; vHPvSD lesions tend to be wider but shallower thereby reducing the potential for extracardiac damage.

However, more worrying are the reports of coagulum formation on the catheter tip and high rates of ACLs which likely represent associated thromboembolic events from this charring (Table 2). Rates of post-procedure ACL in vHPvSD studies have varied from 11.8% to 26%, which are higher than seen with sRF. These have occurred in spite of appropriate intra-procedural anticoagulation, and even after recent software modifications to the nGEN RF generator. Whilst these ACLs were not associated with clinical stroke events, and most (but not all) resolved on follow-up MRI a few months later, recent prospective data suggest that even silent ACLs can be associated with cognitive decline over a relatively short timeframe. As such, it is clearly preferable to minimise – or prevent entirely – the risk of ACL occurrence. How can we do so?

One possible solution is suggested by Mueller *et al.* themselves. While they found catheter tip coagulum in almost a third of patients initially (6 out of the first 19 patients), this stopped happening entirely when the baseline circuit impedance was increased – via repositioning of the neutral electrode – from 90 to 110. This interesting observation lends credence to the theory that coagulum formation results from excessively high current flow with lower impedance. Bourier *et al.* recently demonstrated the critical impact of circuit impedance on ablation, emphasising that it is current delivery, rather than power input, which determines lesion size, and that current delivery can vary widely due to fluctuations in impedance. This effect may be particularly magnified in vHPvSD due to the short duration of current delivery. More research is needed to find the optimal balance of current delivery by modulation of impedance and power, perhaps by development of a 'constant current mode' as suggested by Bourier *et al.* .

vHPvSD ablation represents a quantum leap from the RF settings that have traditionally been used in electrophysiology. If used to its full potential, it may improve procedural efficiency by reducing ablation and procedure times. However, with great power comes great responsibility; we need to ensure that we use it

judiciously and safely (Figure 1). To that end, we are grateful to Mueller and colleagues for highlighting these issues for us to work on.

References

Study	RF Generator / Settings	Inter-tag distance	First Pass Isolation Rate	Total RF time (s)	Need to use standard RF settings, N (%)
QDOT-FAST (2019) N=52	nMARQ 90W / 4sec	Not reported	Not reported*	486	11 (22%)
Halbfass et al.(2021) N=90	nGEN or nMARQ 90W 4sec anteriorly 90W 3sec posteriorly	6 mm anteriorly 6 mm posteriorly	43% of patients 65% of PV pairs	Not reported	51 (57%)
Tilz et al. (2021) N=28	Not reported 90W, 4sec	3-4mm anteriorly 5-6 mm posteriorly	61% of patients 80% of PV pairs	338	0 (0)
Mueller et al. (2022) N=34	nGEN (v1c software) 90W 4sec anteriorly 90W 3sec posteriorly	6 mm anteriorly 6 mm posteriorly	18% of patients 54% of PV pairs	774+/- 594	29 (85%)

Table 1: Studies reporting on the efficacy of very high power very short duration (vHPvSD) ablation for atrial fibrillation. PV – Pulmonary Vein; RF – Radiofrequency.

*First pass isolation figures not explicitly stated; 14(27%) patients had dormant conduction revealed in 20 sites with Adenosine / Isoproterenol challenge after 20 minutes

Study	RF Generator / Settings	Oesophageal Injury	Catheter Coagulum	Cerebral Lesions
QDOT-FAST (2019) N=52	nMARQ 90W / 4sec	1 ulcer haemorrhage, healed with medication	Not reported	No clinical stroke 11.8% (6/51) ACL
Halbfass et al. (2021) N=90	nGEN or nMARQ 90W 4sec anteriorly 90W 3sec posteriorly	None found on endoscopy	None with nMARQ 11% with nGEN	No clinical stroke 24% (5/21) ACL (only with nGEN)
Tilz et al. (2021) N=28	Not reported 90W, 4sec	No clinical events (no endoscopy performed)	None	No clinical stroke ACL not looked for
Mueller et al. (2022) N=34	nGEN (v1c software) 90W 4sec anteriorly 90W 3sec posteriorly	None found on endoscopy	18% with baseline impedance 90, none with 110	No clinical stroke 26% (6/23) ACL

Table 2: Studies reporting on the safety of very high power very short duration (vHPvSD) ablation for

atrial fibrillation. ACL – Asymptomatic Cerebral Lesion; RF – Radiofrequency.

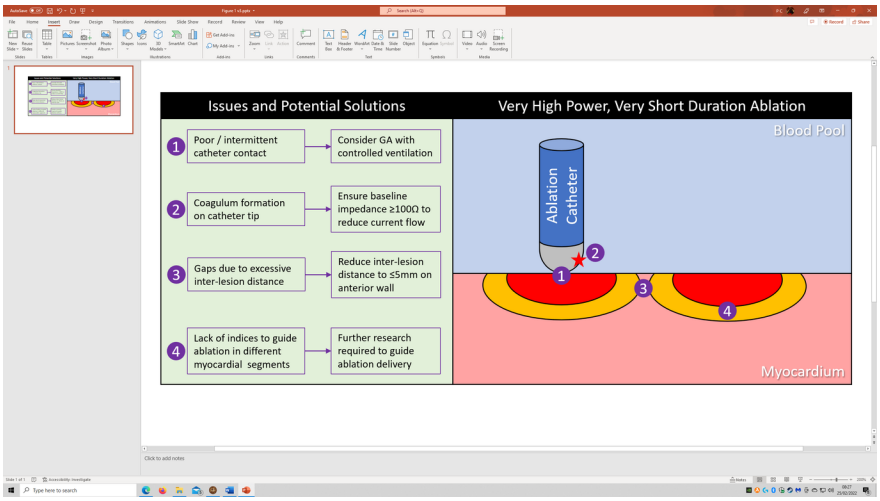

Figure 1: Issues and potential solutions when utilising vHPvSD ablation. GA – general anaesthetic.

Issues and Potential Solutions
Very High Power, Very Short Duration Ablation
1 Poor / intermittent catheter contact
Consider GA with controlled ventilation
2 Coagulum formation on catheter tip
Ensure baseline impedance ≥100Ω to reduce current flow
3 Gaps due to excessive inter-lesion distance
Reduce inter-lesion distance to ≤5mm on anterior wall
4 Lack of indices to guide ablation in different myocardial segments
Further research required to guide ablation delivery
Blood Pool
Ablation Catheter
Myocardium