Recommendations regarding cardiac stereotactic body radiotherapy for treatment refractory ventricular tachycardia

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BACKGROUND Ventricular tachycardia (VT) is a potentially lethal complication of structural heart disease. Despite optimal management, a subgroup of patients continue to suffer from recurrent VT. Recently, cardiac stereotactic body radiotherapy (CSBRT) has been introduced as a treatment option in patients with VT refractory to antiarrhythmic drugs and catheter ablation.

OBJECTIVE The purpose of this study was to establish an expert consensus regarding the conduct and use of CSBRT for refractory VT.

METHODS We conducted a modified Delphi process. Thirteen experts from institutions from Germany and Switzerland participated in the modified Delphi process. Statements regarding the following topics were generated: treatment setting, institutional expertise and technical requirements, patient selection, target volume definition, and monitoring during and after CSBRT. Agreement was rated on a 5-point Likert scale. The strength of agreement was classified as strong agreement (≥80%), moderate agreement (≥66%) or no agreement (<66%).

RESULTS There was strong agreement regarding the experimental status of the procedure and the preference for treatment in clinical trials. CSBRT should be conducted at specialized centers with a strong expertise in the management of patients with ventricular arrhythmias and in stereotactic body radiotherapy for moving targets. CSBRT should be restricted to patients with refractory VT with optimal antiarrhythmic medication who underwent prior catheter ablation or have contraindications. Target volume delineation for
CSBRT is complex. Therefore, interdisciplinary processes that should include cardiology/electrophysiology and radiation oncology as well as medical physics, radiology, and nuclear medicine are needed. Optimal follow-up is required.

CONCLUSION Prospective trials and pooled registries are needed to gain further insight into this promising treatment option for patients with refractory VT.

Introduction

Ventricular tachycardia (VT) generally originates from abnormal electrical foci in structurally normal heart or reentrant circuits in structural heart disease with myocardial scar regions. VT is one of the most common causes for sudden cardiac death. The management of patients with VT consists of treatment of the underlying heart disease as a first step. Often, an implantable cardioverter-defibrillator (ICD) is inserted to reduce the risk of sudden cardiac death. For persistent or refractory sustained VT, antiarrhythmic medication and catheter ablation of the reentrant circuit and potential bystanders have proven to reduce the VT burden and ICD interventions for selected patients. Multiple randomized trials have been conducted over the past decade in patients with post-myocardial infarction VT. Although catheter ablation has proven to be clearly superior to antiarrhythmic drugs in terms of VT burden and time to first VT recurrence, none improved survival. Despite tremendous progress in ablation techniques, the recurrence rate after catheter ablation remain high (40%–60%). However, in spite of these significant technical improvements, reported complication rates of catheter ablation are nonnegligible. Regarding dose-escalated antiarrhythmic drug treatments, complications are relatively high as well. Hence, patients with VT refractory to medical treatment and catheter ablation and/or underlying VT substrates arising at difficult anatomical locations (eg, epicardial substrate after coronary bypass surgery and transmural lesions in hypertrophic myocardium) historically had limited treatment options.

Stereotactic radiotherapy, or more precisely cardiac stereotactic body radiotherapy (CSBRT), was recently explored in patients with limited conventional treatment options. Stereotactic radiotherapy is a form of high-precision external beam radiotherapy (1–12 fractions) for clearly defined target volumes with local ablative radiation doses and has evolved as a treatment alternative to surgery for many tumor sites. Because of fast methodical developments, stereotactic radiotherapy now allows a highly precise and accurate dose deposition in any part of the body. The first VT patient was treated with CSBRT in 2012. CSBRT finally gained significant interest after the first case series and a subsequent prospective clinical trial were published in 2017 and 2019. Since then, numerous case reports, small case series, and some clinical trial results have been published (for review, see references). For Germany and Switzerland, the first cases were reported as early as 2018. In Germany, the prospective RAVENTA (RAdiosurgery for VENtricular TAchycardia) trial (ClinicalTrials.gov identifier NCT03867747) is currently recruiting.

Because patients with recurrent VT after failed catheter ablation have limited treatment options, there is a high clinical need to establish alternative therapies. However, the clinical knowledge about CSBRT is still in its early stages. Until further evidence for CSBRT becomes available, we aimed to develop an expert consensus on (1) the setting of CSBRT, (2) professional expertise and technical requirements, (3) possible indications and contraindications, (4) prerequisites and techniques for target volume definition, and (5) patient monitoring.

Methods

To generate a consensus statement, a modified Delphi consensus was used. Radiation oncologists and cardiologists/electrophysiologists from Germany and Switzerland either having published prior case reports or serving as sites in the RAVENTA trial were invited to participate. Overall, 13 experts participated in the modified Delphi Consensus. The response rate ranged from 92% to 100%.

All surveys were carried out using the online platform SurveyMonkey. The results of the first round were presented at an in-person meeting on October 26, 2019. Using the feedback from the group discussion, relevant questions for CSBRT were identified and respective statements were proposed.

In the second and third rounds, these statements were further consolidated. The fourth round consisted of the first voting round and included 22 statements and multiple-choice questions. A 5-point Likert scale (1 = strongly agree, 5 = strongly disagree) was used. The level of consensus was analyzed using the percent agreement from the 5-point Likert scale. The strength of agreement was classified as strong agreement (≥80%), moderate agreement (≥66%), or no agreement (<66%). The results were presented at a joint videoconference on June 11, 2020. The fifth and final Delphi round included only statements that did not reach previous agreement.

Online consensus rounds were conducted anonymously. The results were analyzed using Microsoft Excel for Mac version 16.32 (Microsoft Corporation, Redmond, WA).
Results

Setting in which CSBRT should be performed

There was strong agreement (84.6%; 11 out of 13) that CSBRT should preferentially be conducted within prospective clinical trials (see Table 1). Furthermore, 92.3% of panelists (12 out of 13) agreed that all treated patients should be included in prospective clinical registries. Still, there was also strong consensus (92.3%; 12 out of 13) that CSBRT may be considered on an individual case-by-case compassionate use basis.

Professional expertise and technical requirements for CSBRT

There was unanimous consensus that the multidisciplinary core team should consist of a cardiologist/electrophysiologist with long-standing professional expertise in the management of patients with cardiac arrhythmia and catheter ablation and a radiation oncologist as well a medical physicist with long-standing professional expertise in stereotactic body radiotherapy (SBRT), respectively (100%; 13 out of 13) (see Table 2). Dedicated programs for catheter ablation (92.3%; 12 out of 13) and SBRT (100%; 13 out of 13) should be established at the institution with state-of-the-art equipment (100%; 13 out of 13). There was strong consensus (100%; 13 out of 13) that the treating institution has to be adequately equipped to manage patients with structural heart disease and recurrent ventricular arrhythmia. Multidisciplinary discussions of patients with refractory VT eligible for CSBRT should include cardiology/electrophysiology, radiation oncology, medical physics, radiology, nuclear medicine, as well as palliative care (92.3%; 12 out of 13). No consensus was reached on the use of higher photon energies or particle therapy (61.6%; 8 out of 13).

Indications and contraindications for CSBRT

The panel strongly agreed that patients with structural heart disease (100%; 13 out of 13) (see Table 3) and an ICD (91.7%; 11 out of 12) with recurrent monomorphic VT (84.6%; 11 out of 13) and/or electrical storm (84.6%; 11 out of 13) are potentially eligible for CSBRT. Patients should also receive optimal antiarrhythmic medication (100%; 13 out of 13). Furthermore, there was a strong consensus (100%; 13 out of 13) that CSBRT should be reserved for patients who experience recurrence after or who have contraindications to catheter ablation.

There was moderate agreement that CSBRT should be used neither in patients with temporary or genetic causes for VT (76.9%; 10 out of 13) nor in case of eligibility for catheter ablation (76.9%; 10 out of 13). The panel strongly agreed that pregnant or breastfeeding patients should not be considered for CSBRT (84.6%; 11 out of 13). No consensus could be reached on whether polymorphic VT or ventricular fibrillation (61.5%; 8 out of 13), advanced heart failure (15.4%; 2 out of 13), ICD malfunction (61.5%; 8 out of 13), prior chest irradiation (30.8%; 4 out of 13), or life expectancy < 6 months (15.4%; 2 out of 13) should be considered as general contraindications.

Determination of the target volume for CSBRT

The panel unanimously agreed (100%, 13 out of 13) that the target volume definition should be an interdisciplinary process on the basis of all available clinical, electrophysiological, and imaging data with consultation of medical physics, radiology, and nuclear medicine as needed (see Table 4). There was also strong agreement (100%; 13 out of 13) that there currently is high uncertainty regarding the optimal size and the exact localization of the target volume as well as for the question whether only the clinical VT or the whole arrhythmogenic substrate should be irradiated. As minimum requirements for target volume definition and delineation, 12-lead electrocardiography (ECG) of the clinical VT (strong agreement, 84.6%; 11 out of 13), invasive and/or noninvasive electroanatomic mapping (strong agreement, 92.3%; 12 out of 13), contrast-enhanced ECG-triggered computed tomography (CT) scan (moderate agreement, 76.9%; 10 out of 13), and time-resolved planning imaging (strong agreement, 92.3%; 12 out of 13) were agreed upon whereas no consensus was reached for cardiac magnetic resonance imaging (30.8%; 4 out of 13) and positron

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Table 1  Setting

| Statement                                                                 | Score frequency | Percent agreement (strength of agreement) | Score median | Voting round |
|---------------------------------------------------------------------------|-----------------|------------------------------------------|--------------|--------------|
| Currently, CSBRT for ventricular tachycardia is still an experimental procedure and should preferentially be performed in the context of prospective clinical trials. | 10 1 1 0 1     | 84.6 (strong)                           | 1            | 1            |
| All patients treated with CSBRT should be included in prospective registries. | 9 3 0 1 0      | 92.3 (strong)                           | 1            | 1            |
| CSBRT may be used in a compassionate use setting in highly selected patients after failure of all established treatment options. | 11 1 0 1 0     | 92.3 (strong)                           | 1            | 1            |

CSBRT = cardiac stereotactic body radiotherapy.
emission tomography/CT or myocardial scintigraphy (15.4%; 2 out of 13).

**Monitoring during and after CSBRT**

There was strong agreement regarding the necessity for continuous ECG monitoring during and after CSBRT as well as the presence of an emergency resuscitation team during treatment (92.3%; 12 out of 13) (see Table 5). Because of the underlying structural heart disease, patients should be closely followed with serial ICD interrogations, ECG, and echocardiography (strong agreement, 100%; 13 out of 13). There was moderate agreement that anticoagulants should be prescribed for at least 4 weeks after the CSBRT procedure (75%; 9 out of 13). The panel strongly agreed that there is insufficient evidence to guide the reduction of antiarrhythmic drugs (100%; 13 out of 13). Thus, the usage and dose of

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**Table 2** Professional expertise and technical requirements

| Statement                                                                 | Score frequency | Percent agreement | Score median | Voting round |
|--------------------------------------------------------------------------|-----------------|-------------------|--------------|--------------|
| The multidisciplinary core team should include an electrophysiologist with long-standing experience in catheter ablation of VT and a radiation oncologist as well as a medical physicist with long-standing experience in SBRT. | 13 0 0 0 0      | 100 (strong)     | 1            | 1            |
| The institution should have a dedicated clinical program for ablation of cardiac arrhythmia with certification by the respective national cardiology society. Standard approaches for endocardial and epicardial ablation should be established. | 8 4 0 0 1      | 92.3 (strong)     | 1            | 1            |
| Technical requirements for electrophysiologic mapping and treatment include a state-of-the-art 3D electroanatomic mapping system. Centers should be experienced in the use of the mapping system for ablation of VT in patients with structural heart disease and in cardiac imaging (cardiac MRI, echocardiography including strain imaging, and PET/CT). | 12 1 0 0 0      | 100 (strong)     | 1            | 1            |
| The institution should have a dedicated clinical program for SBRT with an established workflow including image guidance and appropriate motion management strategies and standard operating procedures according to the DEGRO working group or comparable national or international working groups. | 12 1 0 0 0      | 100 (strong)     | 1            | 1            |
| The institution has to be adequately equipped to monitor and treat patients who are critically ill and present with frequent VT episodes (intensive care unit, mechanical ventilation, and cardiac pacing). | 13 0 0 0 0      | 100 (strong)     | 1            | 1            |
| Current international guidelines for ICD safety should be respected. Photon energies > 6 MeV and particles (eg, protons and heavy ions) should be used with caution in patients with ICD. | 6 2 3 2 0      | 61.6 (none)      | 2            | 2            |
| The clinical management of patients considered for CSBRT should include multidisciplinary discussions with cardiology, radiation oncology, medical physics, radiology, nuclear medicine, and palliative care. | 8 4 1 0 0      | 92.3 (strong)     | 1            | 1            |

3D = 3-dimensional; CSBRT = cardiac stereotactic body radiotherapy; DEGRO = German Society for Radiation Oncology; ICD = implanted cardioverter-defibrillator; MRI = magnetic resonance imaging; PET/CT = positron emission tomography/computed tomography; SBRT = stereotactic body radiotherapy; VT = ventricular tachycardia.
antiarrhythmic drugs should be well documented (100%). Furthermore, quality of life should be studied after CSBRT (100%; 13 out of 13) because of the palliative treatment intent. Treatment-related toxicity should be closely monitored and documented in accordance to published guidelines for SBRT (100%; 13 out of 13). Lastly, there was moderate agreement that chest CT should be performed 8–12 weeks after CSBRT (75%; 9 out of 12).

Discussion

In this article, we provide the first expert consensus on CSBRT for patients with refractory VT. Although its first use dates back only 9 years,6 this is a rapidly moving field. In the past years, 2 prospective studies,8,19 4 retrospective case series,20–22 a growing number of case reports as well as a technical review,10 a systematic review9 and numerous narrative review articles have been published.7,8 The results by the group from Washington University showed a highly significant reduction of VT episodes and ICD interventions with limited toxicity. The latest data from their ENCORE-VT (Electrophysiology-Guided Noninvasive Cardiac Radioablation for Ventricular Tachycardia) trial (ClinicalTrials.gov identifier NCT02919618) with a median follow-up of 23.5 months were reported in 2019.23 At this point, 78% of patients continued to meet the primary efficacy end point. The number of VT episodes was 95.5 during the 6 months before CSBRT, 1 at 0–6 months, 0 at 6–12 months, and 3.5 at 18–24 months after CSBRT. The number of patients on antiarrhythmic drugs at 12 months was still lower than at baseline; however, the number of repeat interventions was not stated. Gianni et al19 recently reported their experience from a prospective pilot trial with 5 patients. All patients had recurrent VT after catheter ablation. During the first 6 months after CSBRT months, 4 of 5 patients (80%) experienced significant reduction in VT episodes with tapering of the antiarrhythmic medication. However, all patients had recurrent VT during follow-up, resulting in repeat catheter ablation in 3 patients (60%). Of note, 2 patients (20%) had significantly compromised target volume coverage of 61% and 65%.

Results from cohorts at other centers have also been mixed. Neuwirth et al22 retrospectively analyzed 10 patients. VT burden was reduced by 87.56% during follow-up; however, 8 of 10 patients (80%) had VT recurrence. Lloyd et al21 also retrospectively reported on 10 patients. ICD intervention data showed a relative reduction of ICD shocks by 68% and of antitachycardia pacing episodes by 48%. One patient was a primary nonresponder and underwent repeat CSBRT. Chin et al20 treated 8 patients with CSBRT. Of

| Table 3 | Indications for CSBRT |
| --- | --- |
| Statement | Score frequency | Percent agreement | Score median | Voting round |
| --- | --- | --- | --- | --- |
| Prerequisites for consideration of CSBRT should include | | | | |
| • Structural heart disease (ICM or NICM) | 9 4 0 0 0 | 100 (strong) | 1 1 | |
| • Placement of an ICD | 8 3 1 0 0 | 91.7* (strong) | 1 1 | |
| • Recurrent monomorphic VT (>3 episodes in the previous 3 mo) | 8 3 2 0 0 | 84.6 (strong) | 1 1 | |
| • Electrical storm | 9 2 1 0 1 | 84.6 (strong) | 1 1 | |
| • Optimal antiarrhythmic medication | 13 0 0 0 0 | 100 (strong) | 1 1 | |
| • One or more previous catheter ablation procedures or contraindications against ablation | 11 2 0 0 0 | 100 (strong) | 1 1 | |
| Which patients should not be considered candidates for cardiac SBRT according to currently available clinical evidence? | | | | |
| • Polymorphic VT/ventricular fibrillation | 5 3 3 2 0 | 61.5 (none) | 2 2 | |
| • Temporary or genetic causes for VT | 8 2 2 1 0 | 76.9 (moderate) | 2 2 | |
| • Eligibility for catheter ablation | 8 2 1 2 0 | 76.9 (moderate) | 2 2 | |
| • Advanced heart failure (NYHA class IV) | 0 2 3 3 5 | 15.4 (none) | 4 2 | |
| • ICD malfunction | 6 2 1 0 4 | 61.5 (none) | 2 2 | |
| • Prior chest irradiation | 1 3 5 2 2 | 30.8 (none) | 3 2 | |
| • Life expectancy < 6 mo | 1 1 3 5 3 | 15.4 (none) | 4 2 | |
| • Pregnant or breastfeeding | 11 0 0 1 1 | 84.6 (strong) | 1 2 | |

CSBRT = cardiac stereotactic body radiotherapy; ICD = implantable cardioverter-defibrillator; ICM = ischemic cardiomyopathy; NICM = nonischemic cardiomyopathy; NYHA = New York Heart Association; VT = ventricular tachycardia.

*One missing response.
note, 3 patients (37.5%) received reduced doses of 15–20 Gy. Median ICD interventions decreased from 69.5 to 13.3 therapies after CSBRT. However, only 3 patients (37.5%) had definite clinical benefit. Of 3 patients with some clinical benefit, 2 later had a reduction of recurrent VT after modification of antiarrhythmic medication, highlighting the role of optimal noninterventional therapy.

In our analysis, no consensus was reached regarding the use of higher photon energies and particle therapy. The use of photon energies above 6 MV and the consequent neutron contamination are well-studied risk factors for device malfunction.24,25 Limited data are available on malfunctions during proton and carbon ion therapy.26,27 In fact, the first use of proton therapy in a patient with VT at the Centro Nazionale di Adroterapia Oncologica in Pavia, Italy, was reported recently.28 Thus, no consensus may have been reached because 2 complex issues were combined in 1 statement.

Regarding exclusion criteria, no consensus was reached for polymorphic VT/ventricular fibrillation. At least 1 case report with successful treatment of a patient with ventricular fibrillation has been published.13 Prior chest irradiation per se was not viewed as an exclusion criterion by several participants. Although this is an exclusion criterion in some prospective trials (RAVENTA14 and Phase I/II Study of 4-D Navigated Non-invasive Radiosurgical Ablation of Ventricular Tachycardia [ClinicalTrials.gov identifier NCT03601832]), other trials have used a looser definition (ENCORE-VT,8 STereotactic RadioAblation by Multimodal Imaging for VT [ClinicalTrials.gov identifier NCT04066517], and Stereotactic Arrhythmia Radioablation for Ventricular Tachycardia Management [ClinicalTrials.gov identifier NCT04065802]). Several participants felt that CSBRT might be feasible in selected patients with limited prior cardiac exposure. Similarly, advanced heart failure and life expectancy < 6 months were not regarded as a major factors precluding CSBRT.

Target volume definition remains a crucial step for radiotherapy in general. When looking at the size of the planning target volume (PTV) in the published literature, there is considerable heterogeneity for CSBRT. In the ENCORE-VT trial, the median PTV was 98.9 mL8 while the PTV

| Statement                                                                 | Score frequency | Percent agreement (strength of agreement) | Score median | Voting round |
|---------------------------------------------------------------------------|-----------------|------------------------------------------|--------------|--------------|
| Target volume definition should be performed by an interdisciplinary team consisting of an electrophysiologist with long-standing experience in electroanatomic VT mapping and a radiation oncologist with long-standing experience in SBRT with consultation of medical physics as well as radiology and nuclear medicine (in case of availability of additional MRI and/or PET-CT/SPECT imaging) | 13 0 0 0 0 | 100 (strong) | 1 1 |
| The optimal size and the exact location of the target volume necessary to successfully treat ventricular arrhythmia are currently unknown. It is currently unclear whether the target volume should include only the clinical VT or the whole arrhythmogenic substrate | 10 3 0 0 0 | 100 (strong) | 1 1 |
| What are the minimum requirements for target volume delineation? | | | |
| Twelve-lead ECG of the clinical VT | 8 3 1 0 1 | 84.6 (strong) | 1 2 |
| Invasive and/or noninvasive electroanatomic mapping | 11 1 1 0 0 | 92.3 (strong) | 1 2 |
| Contrast-enhanced ECG-triggered CT scan | 9 1 1 1 1 | 76.9 (moderate) | 1 2 |
| Time-resolved planning imaging based on the motion management strategy | 11 1 1 0 0 | 92.3 (strong) | 1 2 |
| Cardiac MRI | 3 1 2 5 2 | 30.8 (none) | 4 2 |
| PET/CT or myocardial scintigraphy | 0 2 2 5 4 | 15.4 (none) | 4 2 |

ECG = electrocardiography; MRI = magnetic resonance imaging; PET/CT = positron emission tomography/computed tomography; SBRT = stereotactic body radiotherapy; SPECT = single photon emission computed tomography; VT = ventricular tachycardia.
size ranged from 22.2 to 143 mL for the above-mentioned case series. Of note, the PTV includes a safety margin for motion uncertainties, which depends on the technique used for motion compensation. Boda-Heggemann et al published the first contouring benchmark study from the prospective RAVENTA trial demonstrating limited interobserver agreement as well as considerable variation in transferring the desired target volume from the electroanatomic maps to the treatment planning system.

For catheter ablation, a randomized controlled trial showed superiority in terms of VT recurrence for a substrate-based ablation approach as compared with ablation of only the clinical VT along with mappable VTs. It is important to note that while catheter ablation is an iterative procedure with the ability to monitor acute ablation success, this is not possible for CSBRT. For CSBRT, most groups targeted the VT exit site and/or the VT isthmus. Knutson et al analyzed patients from the ENCORE-VT trial. There was a significant decrease in the delineated target volume over time. There was consensus among the panelists that the optimal size and the exact location of the target volume necessary to successfully treat ventricular arrhythmia are currently unknown. Regarding the minimum requirements for target volume definition, cardiac magnetic resonance imaging and positron emission tomography/CT or myocardial scintigraphy were not considered essential. However, all available information should be used for target volume definition.

Close follow-up is important to monitor the treatment effect and to identify possible treatment-related toxicity. Long-term results from the ENCORE-VT trial identified 3 patients (15.8%) with probable grade 3-4 toxicity. Neuwirth et al identified 1 patient with possibly treatment-related aggravation of preexisting mitral regurgitation. Only moderate agreement was reached regarding the role of anticoagulation after CSBRT. In the initial publication by Cuculich et al, there

Table 5 Monitoring during and after CSBRT

| Statement                                                                 | Score frequency | Percent agreement (strength of agreement) | Score median | Voting round |
|--------------------------------------------------------------------------|----------------|------------------------------------------|--------------|--------------|
| Patients should be closely monitored during and after the procedure with continuous ECG monitoring. An emergency resuscitation team should be available during treatment delivery. | 11 1 1 1 1 | 92.3 (strong) | 1 1 |
| Close cardiology follow-up with monitoring and treatment of the underlying structural heart disease is advised. This should include serial ICD interrogations (VT burden, nsVT burden, ATP, and shocks), ECG, and echocardiography. | 13 0 0 0 0 | 100 (strong) | 1 1 |
| Anticoagulation should be given for at least 4 wk after CSBRT for the prevention of thromboembolic events. | 4 5 2 1 0 | 75* (moderate) | 2 2 |
| The use and the dose of antiarrhythmic drugs should be documented. Currently, there is insufficient evidence to guide the reduction of antiarrhythmic drugs in the context of CSBRT. | 11 2 0 0 0 | 100 (strong) | 1 1 |
| Quality of life should be assessed as a clinically relevant end point because of the palliative intent of the procedure. | 10 3 0 0 0 | 100 (strong) | 1 1 |
| Treatment-related toxicity should be closely monitored and documented in accordance with the published guidelines for lung/thoracic CSBRT. Chest CT should be performed 8–12 wk after cardiac CSBRT to rule out pneumonitis. | 12 1 0 0 0 | 100 (strong) | 1 1 |

ATP = antitachycardia pacing; CSBRT = cardiac stereotactic body radiotherapy; CT = computed tomography; ECG = electrocardiography; ICD = implantable cardioverter-defibrillator; nsVT = nonsustained ventricular tachycardia; VT = ventricular tachycardia.

*One missing response.
was 1 patient who died of a stroke 3 weeks after CSBRT. The patient had not received anticoagulation despite a history of atrial fibrillation and severe cardiomyopathy. Apart from this case, there are no reports of thromboembolic events after CSBRT. The optimal approach regarding antiarrhythmic medication after CSBRT is currently unknown. Data from the Washington University group suggest that the reduction of antiarrhythmic drugs may be feasible.\(^7^,\)\(^8\) In the ENCORE-VT trial, the use of dual antiarrhythmic therapy had decreased at 6 months after CSBRT; however, only 3 patients could discontinue antiarrhythmic medication altogether.\(^5\) Neuwirth et al\(^{22}\) discontinued antiarrhythmic medication in 8 of 10 patients (80%). Despite reproducible effects on VT burden and ICD interventions, quality of life may ultimately be the most important end point in this palliative setting. The ENCORE-VT trial reported significant improvements in 5 of 9 domains.\(^8\)

Only moderate agreement was reached on performing chest CT 8–12 weeks after CSBRT. Arguably, the use of chest CT in asymptomatic patients may be of limited value since asymptomatic radiation pneumonitis usually does not require treatment. Nonetheless, German regulatory authorities mandated follow-up chest CT for the RAVENTA trial.\(^14\) Robinson et al\(^8\) and Lloyd et al\(^{21}\) each reported 2 cases of mild pneumonitis after CSBRT that were treated with steroids.

This Delphi consensus statement was generated by specialized centers in electrophysiology and radiation oncology. Cumulatively, the participating centers have treated ~40 cases using all available treatment platforms, including standard C-arm linear accelerators, robotic radiosurgery, magnetic resonance–guided radiotherapy, and particle therapy. However, considering that the panel consisted of experts from only 2 countries, namely, Germany and Switzerland, as well as the rapidly growing experience in other countries and centers, this is a limitation to the generalizability of our findings. Although the panel contained members from electrophysiology, radiation oncology, and medical physics, subgroup analyses according to these specialties were not conducted because of the limited statistical power.

**Conclusion**

Our consensus statement highlights the knowns and many unknowns of CSBRT. Further prospective trials and generation of pooled cohorts are necessary to gain further insight into this promising treatment option for patients with refractory VT.

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**Appendix Supplementary data**

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrthm.2021.08.004.

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