Radiofrequency Catheter Ablation for Supraventricular Tachycardia

Should It Be Used in Infants and Small Children?

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Catheter ablation for nonpharmacological management of pediatric patients with tachyarrhythmias has evolved during the past approximately 10 years. Direct-current energy ablation was initially used in some patients with drug-refractory, life-threatening tachyarrhythmias such as junctional ectopic-focus tachycardia and also for some children with left ventricular dysfunction due to incessant tachycardias (eg, the permanent form of junctional reciprocating supraventricular tachycardia and atrial ectopic-focus tachycardia).1,2 The extensive lesions and less-than-ideal results from direct-current energy prompted research and development of alternative energy sources that led quickly to clinical application of radiofrequency energy ablation of tachyarrhythmias in adults in the late 1980s. This apparently safer and more successful technique revolutionized the treatment of not only adults but also children and adolescents with supraventricular tachycardia in the 1990s.3-11 The 1992 report of ventricular tachycardia and sudden death during late follow-up of pediatric patients who had undergone direct-current ablation emphasizes the dangers of the direct-current ablation method but also serves as a warning against premature acceptance of any ablation technique because adverse effects may be detected only during late follow-up.12

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In 1990, the Pediatric Electrophysiology Society initiated the Radiofrequency Catheter Ablation Registry to determine the immediate success and complication rates, to monitor technical factors, and especially to provide a cohort of young patients for long-term follow-up. Results from the first 20 months of the Registry (725 procedures in 652 patients; age, 20 days to 20 years; median, 13.5 years) were recently published.13 The immediate and short-term success rates were similar to those in adults, and the acute complication rate of 3.7% as well as the total (including complications detected during follow-up) complication rate of 4.8% were acceptably low.

From the Registry data and other reports of radiofrequency catheter ablation in pediatric patients, practice patterns have emerged regarding indications for the procedure. As with most new options of treatment, a spectrum of opinion among cardiologists has developed regarding recommending radiofrequency catheter ablation for pediatric patients who have supraventricular tachycardia.

Although no data exist regarding actual practice patterns, it is likely that recommendations by pediatric cardiologists reflect a spectrum of opinion regarding indications for the procedure. No doubt some do not recommend the procedure for anything other than life-threatening symptoms because long-term follow-up data are not yet available to warrant elective application. With reassuring short-term follow-up, other cardiologists are quick to recommend the procedure as an appealing alternative to antiarrhythmic drug therapy as well as to the other acceptable management option of "no treatment." Others view radiofrequency ablation as the treatment of choice even in some children with infrequent, self-terminating symptoms for whom pharmacological treatment might not have been traditionally recommended. The infant with drug-refractory tachycardia represents a focal point for the debate over indications for radiofrequency catheter ablation, which begins with the definition of drug refractory.9,14 Some would define drug refractory as symptomatic or frequent asymptomatic recurrent tachycardia after a trial of two or three drugs. In contrast, others believe that virtually all antiarrhythmic drugs and drug combinations need to be exhausted and, moreover, that daily recurrent tachycardia in some patients is an acceptable treatment end point. Some cardiologists also are willing to wait for several weeks while attempting multiple drug regimens, even for patients with incessant tachycardia and left ventricular dysfunction, on the premise that all infants can eventually be successfully treated with an antiarrhythmic drug regimen.15-17 Justification of this approach is based on two considerations: (1) the favorable natural history of infants with supraventricular tachycardia and (2) the risk of the procedure, both immediate and long term.

According to most natural history studies, 60% to 90% of infants with the common type (ie, those that utilize a fast-conducting retrograde accessory atrioventricular pathway) of supraventricular tachycardia no longer need antiarrhythmic drug therapy after a year or even a few months of treatment.18-21 Approximately 20% to 50% of infants with the uncommon types of supraventricular tachycardia (ie, atrial ectopic focus, permanent form of junctional reciprocating type) similarly improve or resolve.22-25 In the Registry, the imme-
diate complication risk of the procedure is statistically
greater in children who weigh less than 15 kg.13 Two of
the four deaths in the Registry were in children in this
weight group. A compelling argument can thus be made
to search aggressively for satisfactory pharmacotherapy
for infants with supraventricular tachycardia to avoid
needless short-term and potential long-term risks of
ablation.

The divergence of opinions available for and against
radiofrequency catheter ablation in infants and in small
children speaks to the need for more data regarding
radiofrequency energy and the immature myocardium.
Saul and his coinvestigators, in this issue of Circulation,
report important infant lamb experiments that provide
important relevant data.26

First, the investigators applied radiofrequency cur-
rent through a catheter electrode with a tip-mounted
thermistor probe to multiple areas on the epicardial
surface of the left ventricle in 15 lambs. The experi-
ments were carried out under direct observation using
well-controlled constant contact pressure in vivo, a
method previously not reported. In contrast to reported
results in adult animals where a linear relation has been
demonstrated for lesion depth as well as for width, a
sigmoid effect of temperature on lesion depth (with
saturation of the temperature effect above 80°C) was
found in the lambs. Because this naturally perfused
epicardial method has not been reported previously, it is
possible that the method is the explanation for this
major difference in findings. Another plausible reason
for the difference relates to animal age/maturity. Saul
and associates offer an intriguing explanation when they
refer to the work of Rakusan et al,27,28 who found
increased capillary density in immature myocardium
that could provide increased local heat transfer.

The second set of experiments provide provocative
clinically relevant data with implications about radiofre-
cyence ablation in infants and small children.

In the 19 infant lambs of the second experiment,
radiofrequency current was applied in a manner similar
to that used clinically in patients (to the endocardial
surface through a transvenous catheter with a 4-mm tip
electrode). Multiple applications of radiofrequency cur-
rent were given with the non–thermistor/thermocou-
pled catheter-tip electrode positioned on the endocar-
dial surface of the atrium, ventricle, and along the
atrioventricular annulus. Three groups of lambs were
euthanized acutely, after 1 month, and after 8.5 months.
Interesting findings are related both to lesion size and to
histology.

Although Saul and his coauthors write that the atrial
lesions (width only) and ventricular lesions (both width
and depth) "clearly increased simultaneously with car-
diac and whole body growth," it was not truly possible
for the investigators to know if the actual lesions
produced were in fact increasing in size. Therefore, it is
more accurate to conclude that the mean lesion size was
statistically different at the two follow-up intervals, and
from this it is reasonable to conclude that the lesions
appeared to have increased during animal growth.

Other limitations in methodology call for caution in
interpretation of these data. While it is admirable that
the investigators monitored the number of radiofre-
cyence applications, only 65% (52% on the atrioven-
tricular [AV] groove, 66% in the atrium, and 79% in
the ventricle) were identified at postmortem examination.
As is supported by the statistically fewer identifiable
lesions on the AV groove, it appears that it was more
difficult to maintain catheter position (and therefore
electrode contact) on the AV groove. Therefore, bias
may have existed toward concluding that the mean
values for AV groove lesion size were not larger among
the three groups. A better record of successful applica-
tion and lesion production may have been achieved by
using a thermistor or thermocoupled ablation catheter.

For these methodological reasons and because it is
difficult to quantify histological data, caution is needed
also when making conclusions based on the histological
findings. Nevertheless, Saul and associates have deline-
ated apparent differences between immature animals
and those reported for adult animals showing more
invasiveness (especially in the ventricle) in the immu-

nure, The authors state: "...the recommendation to attempt to avoid interven-
tion in the youngest patients should probably be fol-
lowed until technical improvements allow for real-time
assessment of lesion size during the ablation proce-
dure." This seems to understate the implications of
the study. Even without the lamb data, the case can be
made for avoiding radiofrequency catheter ablation in
virtually all infants. This is based on the natural history
data (also cited by the authors in their discussion), the
premise that virtually all supraventricular tachycardias
can be controlled with antiarrhythmic drugs, the Regis-
try-demonstrated increased complication risk in chil-
ren who weigh less than 15 kg, and these lamb data that
provide concern for potential future adverse effects
related to the extensive and possible growth-related
expanding myocardial lesions.

If indeed there are some infants and small children
who are candidates for radiofrequency catheter abla-
tion, the data from this lamb study by Saul et al deserve
discussion. If the procedure is performed in patients of
this age group, Saul and coauthors appropriately em-
phasize that every attempt should be taken to ablate as
close as possible to the AV groove, avoiding the ven-
tricular muscle, and utilizing as many technical advance-
ments (eg, small, thermistor/thermocoupled catheters
and short application of low-power current) as possible
to minimize lesion size.

To be fair, various authors have concluded that al-
though radiofrequency catheter ablation is rarely needed
in infants and small children, it can be successfully per-
formed with acceptable success and complication rates
when no therapeutic alternative exists.5,8,11,13,14,29 Al-
though some data exist that have shown a low risk and
high success of treating infants exclusively with the drug
therapy approach, it could be argued that the risk has not
been adequately studied and may in some cases be equal
to or greater than that of radiofrequency catheter abla-
tion. Also, the cost of each approach is an issue. The cost-
comparison is unknown between an ablation procedure
and possibly weeks of hospitalization while finding a
successful drug regimen. Although it has been shown that
radiofrequency catheter ablation is cost-effective in chil-
dren when compared with surgery as well as to years of
medical outpatient follow-up, this has not yet been reported for infants with drug-refractory tachycardia.\textsuperscript{20,31}

Under what circumstances, then, do the data warrant recommending the procedure in infants? Agreement appears to exist that it should not be offered as an equally good or preferred therapeutic option for patients in this age group who present with supraventricular tachycardia and who respond favorably to antiarhythmic drug therapy. Disagreement centers on the following issues: (1) the definition of drug refractory and what constitutes an acceptable medical treatment end point, (2) the definition of life threatening (eg, does this include severe left ventricular dysfunction from incessant tachycardia?), (3) speculative assessment of the risks and cost comparison between exhaustive drug therapy and radiofrequency catheter ablation, and (4) speculation about long-term risks to patients in this age group who have undergone radiofrequency ablation.

Until agreement is reached on operating definitions and more data put speculation to rest, the sobering animal and clinical studies should be considered before performing radiofrequency catheter ablation in infants and small children. Rare situations may warrant recommending the procedure. Infants and small children with congenital heart disease who need intracardiac surgery but who also have an accessory AV pathway may be candidates for preoperative catheter ablation because the risk of additional surgery at the time of operation may be greater than the risk of the catheter ablation. Aside from such unusual extenuating circumstances, the current information does not appear to warrant radiofrequency ablation in infants with drug-refractory supraventricular tachycardia at this time.

References


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