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Immediate and long-term efficacy and safety of catheter ablation of right anteroseptal atrio-ventricular accessory pathways

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ABSTRACT

This study investigated long-term outcome of catheter ablation of right anteroseptal atrio-ventricular (AV) accessory pathways (AP) located close to the His bundle.
Methods: Between April 2003 and June 2011, 26 patients (6 females, age 35 ± 13 years) underwent catheter ablation of right anteroseptal AP. These APs represented 10% of all 248 APs ablated within the given reference period. Elimination of AP conduction in both directions and preservation of normal AV conduction were the ablation procedure endpoints.
Results: First ablation was effective in 18 (69%) patients. After repeat ablation, AP was permanently eliminated in 22 (85%) patients (one, two, and three ablation procedures in 16, 5, and 1 patient, respectively). Ablation failed in 4 patients (1 procedure in 3 patients, 2 procedures in 1 patient). During 56 ± 27 (4–102) month follow-up period since the last ablation, no late AP conduction recovery was found, and no late advanced AV block occurred. Post-ablation AV node Wenckebach point was present at the pacing rate of 176 ± 26 (130–230) beats per minute. Of the two engaged operators, more experienced operator successfully accomplished first, second, and third ablation procedure in 14/16 (88%), 5/5 (100%), and 1/1 (100%) patients, respectively, the latter operator attained successful ablation in 4/10 (40%) and 1/2 (50%) patients at the first and second ablation procedures, respectively.
Conclusion: Ablation of right anteroseptal AP close to the His bundle is feasible and safe. Late advanced AV block was not observed. Individual operator's experience influenced ablation efficacy.

Klíčová slova:
Hisův svazek
Katetrová ablace
Přídatná dráha

SOUHRN

Cílem práce byla analýza dlouhodobých výsledků katetrové ablace pravostranných anteroseptálních atrioventrikulárních (AV) přídatných drah (PD) v blízkosti Hisova svazku.
Metody: Katetrovou ablaci pravostranné anteroseptální PD podstoupilo od dubna 2003 do června 2011 26 pacientů (6 žen), průměrného věku 35 ± 13 let. Tyto PD představovaly 10 % ze všech 248 PD řešených ablací za dané referenční období. Cílem výkonu byla eliminace vedení PD v obou směrech a zachování normálního AV vedení.

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Výsledky: První ablace byla bezprostředně úspěšná u 18 (69 %) pacientů. Celkem bylo dosaženo trvalé eliminace vedení PD u 22 (85 %) pacientů (jeden, dva, respektive tři výkony u 16, 5, respektive jednoho pacienta). Naopak u čtyř pacientů byla ablace neúspěšná (jeden výkon u tří pacientů, dva výkony u jedné pacientky). Po dobu 56 ± 27 (4–102) měsíců sledování nedošlo k žádné opožděné recidivě vedení PD a u nikoho se nerozvinula opožděná AV blokáda vyššího stupně. Pro ablaci byl Wenckebachův bod na AV uzlu přítomen při stimulační frekvenci 176 ± 26 (130–230)/minutu. Ze dvou angažovaných vyšetřujících dosáhl zkušenější bezprostřední úspěšnosti prvního, druhého, respektive třetího výkonu ve 14/16 (88 %), 5/5 (100%), respektive 1/1 (100%) případech; druhý vyšetřující měl úspěšnost prvního výkonu 4/10 (40%) a druhého výkonu 1/2 (50%).

Závěr: Ablace pravostranné anteroseptální PD je proveditelná účinně a bezpečně. Nebyl zaznamenán pozdní vývoj pokročilé AV blokády. Zkušenost vyšetřujícího ovlivnila účinnost ablace.

Introduction

Catheter ablation of atrio-ventricular (AV) accessory pathways (APs) has proved to be highly successful and safe curative method [1,2]. AP location in vicinity of the AV node and His bundle increases the risks of AV conduction block, sets the operator higher demands to make adequate decisions, and decreases ablation efficacy [3–7]. On account of general decrement in the number of patients undergoing AP ablation, and relatively rare occurrence of APs located close to the AV conduction system, there is a considerable shrinkage of opportunity for younger electrophysiologists to encounter and successfully/safely manage complex AP forms.

This study included patients with right anteroseptal APs localized in vicinity of His bundle. Immediate and long-term efficacy and safety of AP ablation carried out in one center within a period of eight years were evaluated.

Methods

Study population

Between April 2003 and June 2011, 26 patients (6 females), aged 35 ± 13 (19–59) years, underwent catheter ablation of a right anteroseptal AP located close to the His bundle. These APs represented 10% of all 248 APs in 247 patients who underwent AP ablation within the given reference period. Ablation was indicated for recurrent symptomatic orthodromic AV reentry tachycardia (oAVRT), seven (27%) patients had history of syncope, which was connected with head injury and subdural hematoma in one case. One patient was resuscitated for ventricular fibrillation prior to his last ablation procedure. Eight (31%) patients previously underwent one to three unsuccessful AP ablation procedures elsewhere (details in Table 1). Only patients, who were given at least one ablation energy delivery, were included into the analysis. Four patients, who, following the diagnostic part of the study, were decided not to be ablated, were

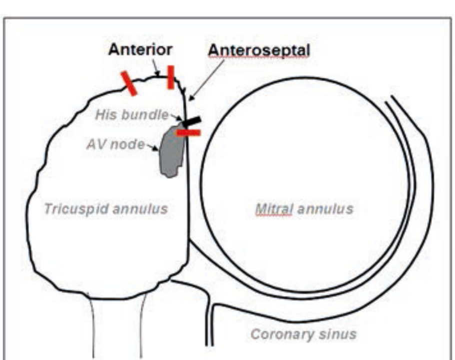

Fig. 1 Diagram showing location of right-sided anteroseptal accessory pathways in vicinity of the His bundle. True para-hisian pathways represent a subset of pathway located immediately next to the His bundle. Approximately left anterior oblique view of the valve annuli.

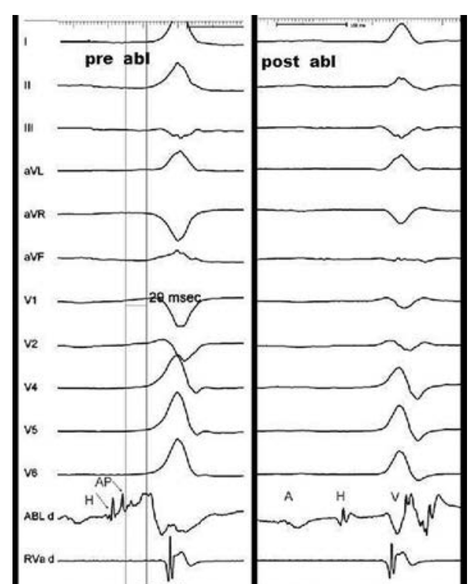

Fig. 2 An example of successful manifest para-hisian accessory pathway ablation. During sinus rhythm before ablation, 12-lead surface ECG shows preexcited QRS complex, and the distal electrode bipole of the ablation catheter (ABL d) records simultaneously local His bundle potential (H) and accessory pathway potential (AP). Following ablation and AP conduction elimination, preexcitation disappeared and a typical His bundle recording of non-preexcited sinus beat was revealed exhibiting distinct high-frequency His bundle potential.

RVa d – intracardiac bipolar recording from the right ventricular apex.

Table 1 – Baseline characteristics.

N.	M/F	Age (yrs)	Symptom history (months)	N. AAD	Syncope	CPR	N. prior ablations elsewhere	N. ablation procedures	Follow-up (months)
1	M	55	9	2	+		0	1	102
2	F	21	4	1	+		1	1	99
3	M	19	15	1			0	2	86
4	M	50	30	4	+		1	2	86
5	M	32	16	1			1	1	86
6	M	27	14	1			0	2	84
7	M	48	8	2			0	1	83
8	M	35	15	2			1	1	81
9	M	41	20	1	+		0	1	78
10	M	40	23	4	+	+	2	2	62
11	M	59	31	3			1	1	67
12	F	19	9	2			1	1	61
13	M	38	10	2			0	3	45
14	F	55	20	2			0	2	46
15	F	28	15	1	+		3	1	47
16	M	32	8	1	+		0	1	47
17	F	22	15	0			0	1	47
18	F	51	10	2	+		0	2	39
19	M	36	17	0			0	1	44
20	M	46	12	1			0	1	42
21	M	24	6	2			0	1	30
22	M	20	2	2			0	1	28
23	F	27	5	1			0	1	22
24	M	43	18	0	+		0	1	22
25	M	25	13	1			0	1	18
26	M	23	16	0			0	1	4

AAD – antiarrhythmic drugs; CPR – cardio-pulmonary resuscitation for ventricular fibrillation; F – female; M – male; N. ablation procedures – number of ablation procedures performed in referring center, yrs – years.

excluded. Two patients with right midseptal AP, i.e. AP located beneath the His bundle close to the compact AV node, were also excluded.

Definitions

Tricuspid annulus is basically triangular in shape tapering towards its upper-anterior part, at the septal aspect of which the His bundle is located. This study included patients with AP localized at the anterior (superior) septal segment of the tricuspid annulus within 10 mm from the His bundle, i.e. in the segment bounded by the apex of the tricuspid annulus superiorly and His bundle inferiorly (Fig. 1). According to the standard nomenclature, these APs are usually classified as anteroseptal. APs, after ablation of which a distinct high-frequency His bundle potential was recorded, were designated para-hisian APs (Fig. 2), nevertheless at least a tiny far-field His bundle potential was recorded at the site of successful ablation in all included patients corroborating proximity of both the AP and the His bundle.

Electrophysiological study

For the electrophysiological study, diagnostic catheters were deployed in the right ventricle (4-pole catheter, Biosense-Webster, Diamond Bar, CA, USA) and coronary sinus (10-pole catheter [Daig, St. Jude, Minnetonka, MN, USA]), and a mapping/ablation catheter was introduced. In addition, a 4-pole diagnostic catheter could be placed for continuous His bundle recording. Surface electrocardiograms and bipolar endocardial electrograms were filtered at a band-pass setting of 30–500 Hz and recorded digitally (Cardiolab System, Prucka Engineering, Sugar Land, TX, USA), and maximum amplification gain 10,000 for mapping signal was used on the mapping/ablation catheter. During the diagnostic part of the procedure, retrograde and antegrade (in manifest APs) conduction capacity, i.e. pacing rate at which the VA or AV activation remained in 1 : 1 relation, were determined, and oAVRT was induced. After ablation, Wenckebach point of the AV node, and AH and HV intervals were measured (they could be also assessed before ablation in patients with concealed AP), and retrograde conduction capacity of the AV node (VA dissociation or the so-called retrograde Wenckebach point of the AV node) were further ascertained.

Catheter ablation

Ablation catheter was primarily introduced from the femoral vein via inferior vena cava and may have required stabilization on the tricuspid annulus by a long sheath. In some cases of inadequate catheter stability at the ablation site, the catheter was secondarily introduced from the subclavian or jugular access for "hooking" and

Table 2 – Ablation procedure characteristics and results.

N.	AP location	Manif /Conc	Antegrade AP Cond. (bpm)	Retrograde AP Cond. (bpm)	AP Elim –	AP Elim +	SVC access	Abl. energy	WP	rWP	Op
1	AS	Manif	240	250		1		RF	160	Dis	A
2	AS	Conc	Na	280		1	1	RF	150	120	A
3	AS	Manif	200	230		1		RF	210	170	A
		Conc	NA	220		1		RF	220	170	A
4	P-H	Manif	260	270	1 el			RF	NA	NA	A
		Manif	250	240		1		Cryo, RF	180	180	A
4	AS	Manif	160	190		1		Cryo	180	180	A
6	P-H	Manif	210	190		1		RF	160	Dis	A
			210	190		1		Cryo	180	Dis	A
7	AS	Conc	NA	250		1		RF	230	150	A
8	AS	Conc	Na	240		1		RF	180	Dis	A
9	P-H	Conc	Na	220		1		RF	170	120	A
10	P-H	Manif	210	220	1			RF	NA	NA	A
		Manif	200	200		1		RF cool	130	130	A
11	AS	Manif	180	200		1		RF	170	Dis	A
12	P-H	Manif	190	210		1	1	RF	180	Dis	A
13	P-H	Manif	180	190	1 el			RF	NA	NA	B
		manif	Rudim	180		1		RF cool	190	Dis	A
		manif	Rudim	180		1		RF cool	180	Dis	A
14	P-H	Manif	250	250	1			RF	NA	NA	B
		Manif	230	250		1		RF	140	Dis	B
15	AS	Manif	220	220		1		RF cool	190	160	A
16	AS	Manif	250	250		1	1	RF	180	220	B
17	AS	Manif	250	250		1		RF	200	200	B
18	P-H	Manif	210	200	1 el			RF	NA	NA	B
		Manif	230	200	1 el			RF	NA	NA	B
19	AS	Manif	180	200		1	1	RF cool	200	210	A
20	P-H	Conc	NA	200	1 el			RF cool	NA	NA	B
21	P-H	Manif	250	220		1		RF cool	230	230	B
22	P-H	Manif	120	160	1 el			RF	140	NA	B
23	AS	Conc	NA	230		1		RF cool	150	Dis	A
24	P-H	Conc	NA	180		1		RF cool	160	Dis	B
25	P-H	Conc	NA	160	1 el			RF cool	150	NA	B
26	P-H	Manif	130	220		1		RF	170	120	A

AP – accessory pathway; AP Elim – – technical failure to eliminate AP; AP Elim + – technically successful AP elimination; AS – anteroseptal; Conc – concealed; Cond – conduction; cryo – cryoablation; Dis – retrograde ventriculo-atrial dissociation during ventricular pacing; el – elective premature procedure termination; Manif – manifest; Op – operator; P-H – para-hisian; RF – temperature-controlled radiofrequency ablation; RF cool – cooled power controlled radiofrequency ablation; Rudim – rudimentary antegrade AP conduction; rWP – retrograde Wenckebach point of AV node; SVC access – ablation via subclavian/jugular vein and superior vena cava; WP – Wenckebach point of AV node.

stabilizing the catheter at the apex of the tricuspid annulus from above via superior vena cava. Temperature-controlled ablation delivered through the catheter with a standard 4 mm tip (22 procedures) or occasionally cryoablation (3 procedures) were employed mainly during the first years, while power-controlled ablation via catheter with irrigated 3,5 mm tip electrode (10 procedures) was largely used in the later years (Table 2). Radiofrequency energy was applied with a Stockert generator (Biosense Webster). Irrigation of 17 ml/min (0.9% saline) through a Cool Flow pump (Biosense-Webster), and temperature and power limits of 42 °C and 30 W; respectively, were used. Cryoablation at –70 °C was applied as a 6-minute-lasting individual delivery through the catheter Freezor (Cryocath Technologies Inc., Montreal, Quebec, Canada).

The site of ablation was determined by standard mapping criteria. The earliest local atrial activation during retrograde VA conduction was searched during ventricular pacing or ongoing oAVRT. If then ablation energy delivery was not feasible in sinus rhythm, it was preferentially applied during ongoing oAVRT and not ventricular pacing to avoid masking of impending conduction block over the AV node/His bundle. The earliest local ventricular activation in relation to the onset of delta wave of the QRS complex on the surface ECG (V-delta) was determined during sinus rhythm or atrial pacing. Ablation was preferentially performed during sinus rhythm to monitor AV conduction and detect possible junctional rhythm. Similarly, in concealed APs, once the AP was localized by successful ablation energy delivery during oAVRT, ablation was finished by subsequent energy delivery during sinus rhythm.

After the diagnostic part of the procedure, the operator discussed and explained to the patient all risks inherent to the ablation in given location and ablation was performed only with the patient's consent. During subsequent procedure course, if the AP location appeared too risky to the operator, ablation could be electively prematurely terminated.

Elimination of the AP conduction in both directions was the procedure endpoint, and the result was checked and tested by ventricular and atrial pacing for at least 30 minutes. Then, after determining AV node and His bundle conduction characteristics, the procedure was terminated.

Follow-up

Patients were seen in the outpatient department within the first three months after ablation and then were contacted over telephone or were repeatedly seen on the out-patient basis when needed. They were screened for palpitations and other arrhythmic symptoms and for prospective delayed AV conduction disturbance and pacemaker implantation.

Statistical analysis

Data were expressed as mean ± standard deviation or proportions.

Results

AP characteristics

AP locations are shown in Table 2. Eighteen (69%) patients had a manifest AP and 8 (31%) patients exhibited a concealed AP. First ablation that was followed by AP conduction recovery significantly changed AP conduction parameters in two patients. In both instances, original antegrade manifest AP conduction with a relatively high conduction capacity either entirely disappeared (n = 1) or remained rudimental (n = 1), while the retrograde conduction did not significantly change.

Prior to the first ablation, in patients with manifest AP, antegrade AP conduction allowing 1 : 1 AV activation during atrial pacing was present up to the pacing rate of 207 ± 42 (120–260)/min (n = 18), while retrograde AP conduction with 1 : 1 VA activation during ventricular pacing was present up to the pacing rate of 218 ± 31 (160–280)/min (n = 26).

Repeat ablation and outcome

One and two repeat ablations were performed in 7 and 1 patients, respectively. In total, 34 ablation procedures were performed. First ablation was technically successful in 18 (69%) patients. AP conduction recovered with delay in 2 of these patients. In both instances, the AP conduction recurrence was successfully treated by repeat ablation.

First ablation failed to eliminate AP conduction in 8 (31%) patients. In 2 patients, AP ablation failed despite all standard efforts to accomplish the procedure; repeat ablation was successful in both these patients. In another 6 patients, ablation procedure was electively prematurely terminated after consultation with the patient. Two of these patients subsequently underwent a successful repeat ablation, with further AP conduction recurrence in 1 patient that was eventually successfully managed by a second repeat ablation. One patient underwent unsuccessful repeat ablation that was again prematurely terminated for safety reasons. Three patients were not offered further ablation.

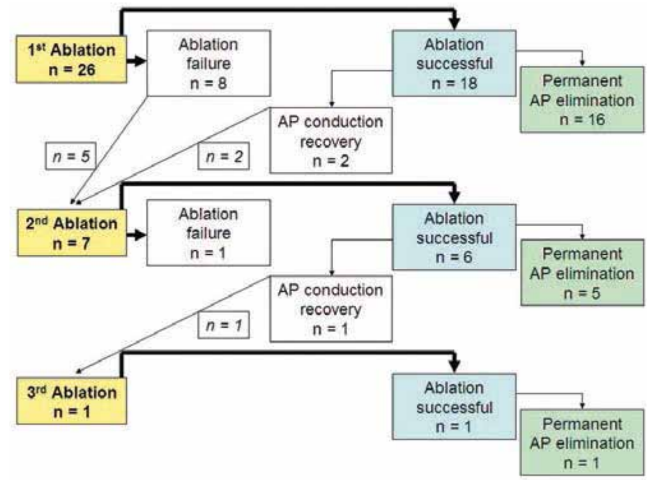

Fig. 3 – A flow-chart showing immediate technical ablation results and subsequent clinical outcome.

In total, AP conduction was permanently eliminated in 22 (85%) patients (in 16 patients by 1 procedure, in 5 patients after 2 procedures, and in 1 patient after 3 procedures). In contrast, the procedure was electively prematurely terminated in 4 patients (1 procedure in 3 patients, 2 procedures in 1 patient) (Table 2, Fig. 3). All 4 (33%) failed ablation procedures were present in patients with true para-hisian APs (n = 12) (Table 2).

Procedure, fluoroscopy and ablation energy application time

Mean procedure, fluoroscopy, and radiofrequency energy delivery times were 139 ± 71 (60–270), 14 ± 10 (2–41), and 12 ± 10 (1–34) minutes. In addition, cryoablation was employed in 3 patients. Cryoablation by freezing at –70 °C was successful in 2 patients (one and three applications, respectively), while cryoablation with 13 applications at –70 °C failed to eliminate AP in another patient; nevertheless, this procedure was eventually successfully completed with radiofrequency ablation. Catheter had to be stabilized by long sheath in 2 instances, and ablation was successfully finished by introducing catheter via the subclavian or jugular approach in another 4 cases (Table 2).

Ablation energy

Temperature-controlled radiofrequency ablation was successfully used in 12 patients at the first ablation procedure, and in 3 patients at the second procedure. It failed in 6 cases of the first procedure and one case of the second procedure.

Power-controlled cooled radiofrequency ablation was successfully employed in 5 instances of the first procedure, 2 instances of the second procedure, and one third ablation procedures. It failed in two instances of the second procedure.

Cryoablation was successfully used in one case of the first ablation procedure and one case of the second ablation procedure. It failed in one case of the second ablation that was successfully completed by temperature-controlled radiofrequency current (see above).

In summary, temperature-controlled radiofrequency ablation was used successfully in 15 (68%) cases and unsuccessfully in 7 (32%) cases, power-controlled radiofrequency ablation was used successfully in 8 (80%) cases and unsuccessfully in 2 (20%) cases, and cryoablation succeeded in 2 (67%) cases and failed in one (33%) case.

AV nodal and His bundle conduction characteristics after ablation

Retrograde conduction over the AV node could not be assessed due to ineffective ablation in four patients. Antegrade AV nodal conduction was not ascertained in one patient with ineffective ablation and AP conduction capacity exceeding AV nodal conduction. In the remaining patients with successful ablation, AV nodal Wenckebach point after the last ablation was present at the pacing rate of 176 ± 26 (130–230) bpm. No patient developed grade I–III AV block. When assessing retrograde AV nodal conduction, 9 patients displayed complete VA dissociation, and another 13 patients exhibited retrograde Wenckebach point of the AV node at the pacing rate 168 ± 39 (120–230) bpm (Table 2). AH and HV intervals were in normal range in all patients. Pacemaker was later implanted in one patient for intermittent pauses due to sino-atrial node dysfunction.

Long-term outcome

All patients (n = 22/85%) with successful AP ablation remained without AP conduction recurrence for 56 ± 27 (4–102) months since the last ablation. No delayed higher degree AV block requiring pacemaker implantation occurred. Patient #10 with implanted pacemaker for sinus pauses underwent later another electrophysiological study for isolated syncope connected with documented atrial fibrillation. AP conduction recurrence was excluded and normal AV nodal and His bundle conduction parameters were proved, specifically AV nodal Wenckebach point was present at 160 bpm.

Operator's experience and results

Out of the four operators performing AP ablation within the reference period, two operators (denominated A, B) were directly engaged in ablation of anteroseptal AP close to the His bundle (Table 2). Operator A carried out all ablation procedures in 16 patients, and two repeat ablations in 1 patient whose first ablation was performed by the operator B. Operator's A immediate success rate of the first ablation procedure was 14/16 (88%), of the second procedure 5/5 (100%), and of the third procedure 1/1 (100%). Operator's B immediate success rate of the first procedure was 4/10 (40%) and of the second procedure 1/2 (50%). In total, operator A eventually succeeded in all 18 patients in whose ablation he was engaged. Operator B eventually ablated 5 patients successfully, while electively terminated the procedure in other 5 patients (two times in one patient).

Discussion

The results of this retrospective analysis of patients undergoing catheter ablation for right anteroseptal AP located close to the His bundle are as follows: 1) Catheter ablation is feasible and safe in most of the patients and ablation failure usually results from elective decision to terminate the procedure prematurely; 2) outcome was not affected by the type of used ablation energy, cooled power-controlled radiofrequency ablation was utilized safely in all cases; 3) ablation success was influenced by the operator's experience; 4) in long-term, no late AP conduction recurred and no late higher-degree AV block developed.

In the modern era, catheter ablation of APs exceeds 90% success rate even after the first ablation procedure, and improves nearly to 100% after repeat ablation with minimal risk of complications 100% [1,2]. Yet, APs located in the vicinity of the AV node/the His bundle place patients and operators before difficult decisions and technical challenges. Earlier pioneering studies have demonstrated ablation of anteroseptal (above the His bundle) or midseptal (beneath the His bundle) APs largely feasible, although the risk of higher-degree AV block cannot be excluded [3–7]. These APs are fortunately relatively rare, and likewise in our study, have been previously shown in approximately 10% of the patients undergoing AP ablation [2,5,8]. Relative safety of ablation of APs confined to the segment of the tricuspid annulus above the His bundle may lie in their common superficial endocardial position, while the His bundle gets buried into the membranous ventricular septum enveloped and protected against injury by the fibrous casing. Therefore, the ablation effect on the AP can be partly dissociated from the His bundle despite proximity of both the structures.

Little is known on the late effect of ablation near AV conduction system. Delayed AV conduction block after septal ablation is possible [9]. In the subacute phase, it can be caused by extension of the coagulation due to the marginal microvasculature damage. However, very late negative impact of uncomplicated ablation in the parahisian location can be also speculated. Late AV block resulting largely from spontaneous degenerative changes particularly in older patients can be facilitated by previous permanent ablation-induced destruction of some inputs into the AV node. In our study, however, no late higher-degree AV block occurred (and at the same time, no delayed AP conduction recovery was observed) during the 56 ± 27 month follow-up, although 12 patients underwent ablation more than 5 years ago, and 9 of them underwent ≥ 2 ablation procedures in our center or elsewhere. In addition, at the time of ablation, 5 patients were ≥ 50 years old and another 5 patients ≥ 40 years old.

Right anteroseptal AP ablation efficacy is high despite unfavorable location and can exceed 90% [7]. In our study, first ablation procedure failed in 8 (31%) patients, nevertheless, the result was mainly influenced by guarded approach leading to relatively frequent premature procedure termination. If the ablation had not been commenced at all in 6 patients, in whom the procedure was electively terminated, the first ablation efficacy would have changed to 18/20 (90%). We repeated ablation in 7 (27%) patients (prior ablation procedures completed in other centers were not calculated). In total, ablation was successful in 22 (85%) patients. Repeat ablation was not indicated in three patients, and again prematurely terminated in one patient. Although two most experienced operators were engaged, long prior experience with the ablation method proved to influence final result importantly.

Risky AP location incited use of alternative ablation energies and mapping techniques, first of all cryoablation [10,11], or electromagnetic navigation [12,13] that might in theory reduce the risk of AV conduction damage by specific nature of the myocardial lesion formation, or by decreasing the risk of catheter dislocation during energy delivery. In our study, the energy used (temperature-controlled or cooled power-controlled radiofrequency or cryoablation) did not affect ablation success rate; however, cryoablation was employed in only three cases. On the other hand, cooled power-controlled radiofrequency ablation, which produces larger lesion and might be regarded more aggressive, was routinely used in the later stages of the referring period to improve AP ablation efficacy in general, and proved to be safe without inadvertent AV conduction damage also in the right anteroseptal region.

Conclusion

Catheter ablation of right anteroseptal AP located close to the His bundle can be accomplished highly effectively and safely without complicating AV conduction block. Ablation efficacy was not essentially dependent either on the ablation energy or modification of its delivery. Successful ablation was significantly influenced by individual operator's experience.

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