Coll. Antropol. **27** Suppl. 1 (2003) 83–91
UDC 616.12-008.31:615.84
Original scientific paper

Long-Term Results and Learning Curve for Radio Frequency Ablation of Accessory Pathways

Robert Bernat[1] and Dietrich Pfeiffer[2]

[1] Hospital for Cardiovascular Surgery and Cardiology »Magdalena«, Krapinske Toplice, Croatia
[2] Department of Cardiology, University of Leipzig, Leipzig, Germany

A B S T R A C T

Radio frequency (RF) catheter ablation of accessory pathways represents an interventional method in modern cardiology that has become the first-line treatment for patients with symptomatic WPW-syndrome. The aim of this study was to analyze: (1) the learning curve for the ablation procedure; (2) procedural parameters and success; and (3) personal assessment of the treatment by the patients. Learning curve analysis included 195 consecutive patients, who underwent ablation between 1991 and 1996. The follow-up survey included 65 consecutive patients. The analysis of the procedural parameters showed significant improvement after 100 cases, implying a completion of the learning curve at this point. Long-term follow-up showed a high success rate for all pathways (95.4%). All procedure parameters indicated significantly higher degree of difficulty for right free-wall and septal pathways, with lowest long-term success rate for right-sided pathways (78.6%). Personal assessment survey showed high acceptance of the treatment; the procedure was described as a significant improvement of overall quality-of-life by 92.3% of patients. The results of this study confirm the catheter ablation of accessory pathways – in particular after completion of the learning curve – as a low-risk and highly efficient treatment for symptomatic WPW-syndrome, with a high degree of patient-related acceptance.

Key words: *WPW-syndrome, catheter ablation, accessory pathways.*

Introduction

Treatment for patients with symptomatic supraventricular tachycardia mediated by reentry through an accessory pathway is based on two modalities: palliative and curative therapy. The first group includes antiarrhythmic medica-

Received for publication January 7, 2002

tion and implantation of antitachycardia-pacemakers. While the latter option is virtually obsolete in this group of patients, the life-long drug therapy carries the burden of numerous adverse effects and possible proarrhythmic action. Surgical interruption of accessory pathways was used to cure the arrhythmia, albeit with risks and costs associated with open-heart surgery. With the introduction and the subsequent technical advances in the procedure of radio frequency (RF) catheter ablation, a new possibility has emerged for definitive treatment of reentrant tachycardia in the WPW syndrome, which carried low risk and high efficacy.

The electrocardiographic syndrome of functional bundle branch block and shortened PR-interval in otherwise healthy young individuals with paroxysmal tachycardia was first described by Wolff, Parkinson and White in 1930[1]. Contemporary epidemiological data estimate the incidence of accessory pathway (Kent bundle) as an anatomical basis for the disorder at 1.5 to 4/1,000 individuals[2], with approximately one-half experiencing symptoms[3]; this makes the WPW syndrome a common cause of paroxysmal supraventricular tachycardia.

The majority of accessory pathways exhibit anterograde, as well as retrograde conduction capability. If an exclusively retrograde conducting Kent bundle is encountered (up to 30%), it is designated as concealed pathway, with no typical morphology on the surface ECG in sinus rhythm, i.e. without the delta wave. The accessory pathway can be located in any of the regions alongside the tricuspid and mitral annulus. Although the conduction properties and location may be suspected from the surface and/or tachycardia ECG recording, their definitive characteristics with respect to electrophysiologic properties (such as unidirectional retrograde or anterograde conduction or bidirectional conduction; refractory period; involvement in the reentry tachycardia) and anatomical location (left or right free wall, anteroseptal, midseptal, posteroseptal) are determined during an electrophysiological study.

Techniques for catheter ablation of the His bundle were introduced in 1982[4,5]. Initially, direct-current shocks were used, but this energy source has been virtually replaced by RF energy, which is delivered from an external generator and produces small defined tissue lesions of the endocardium. By the beginning of the 1990s, catheter ablation has become the treatment of first choice for accessory pathways, with reported success rate well above 90% and extremely rare solitary complications[6–8]. The procedure involves intravascular (venous or arterial, depending on the location of the pathway) placement of ablation catheter, mostly through the transfemoral approach, at the presumed position of the accessory pathway. The correct placement of the catheter is guided by intracardiac ECG, as well as by fluoroscopy. Then, RF energy is delivered between the catheter tip and an indifferent electrode pad on the patient's back. This produces local heating up to 60–70 °C, resulting in a coagulation necrosis with a 3–5 mm radius around the tip, thus interrupting the conduction through the pathway.

Patients and Methods

Catheter ablation

Initially, a standard electrophysiologic study (EPS) was performed in each patient, with insertion of up to 4 diagnostic electrodes to different regions of the heart (typically, right atrium, coronary sinus, right and left ventricle). Intracardiac mapping allowed determination of electrophysiological characteristics and precise anatomic location of the pathway, as well as induction and analysis of corre-

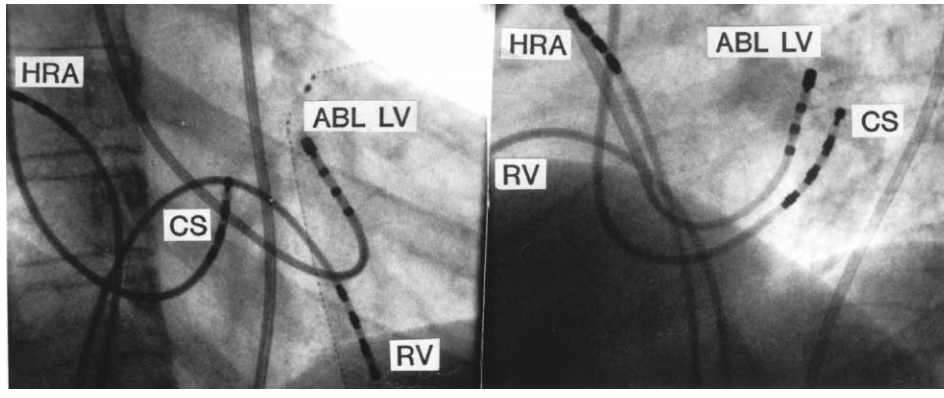

Fig. 1. Placement of diagnostic and ablation catheters during ablation of a left free wall accessory pathway: high right atrium (HRA), right ventricle (RV), coronary sinus (CS), left ventricle (ABL LV). RAO 30° and LAO 60° fluoroscopic projections.

sponding reentry tachycardia. After confirming the indication for ablation during the EPS, procedure was performed using a steerable ablation catheter, maneuvered under x-ray fluoroscopic control in typical LAO 60° and RAO 30° positions (Figure 1). Transfemoral venous, retrograde arterial or, occasionally, transjugular (for right-sided pathways) approach was used.

Learning curve

The clinical characteristics of 195 consecutive patients included in the analysis of the learning curve for typical ablation parameters are shown in Table 1. Four parameters of the ablation procedure were analyzed in order to determine the completion of the learning curve: procedure duration (minutes), fluoroscopy duration (minutes), number of RF-impulses (n), and total energy delivered (W). For the purpose of learning curve analysis, patients were divided into 4 consecutive groups, each comprising 50 patients, except for the last group, which had 45 patients. Procedural parameters were also compared for patients who had evidence of concomitant atrial fibrillation (AF), and with respect to conduction properties

TABLE 1
CLINICAL DATA FOR 195 PATIENTS (107 MALES, 88 FEMALES, AGED 11–74 YRS. (38.9 ± 15.2) INCLUDED IN THE LEARNING CURVE PROCEDURE PARAMETER ANALYSIS

Tachycardia	
Since (years)	16.0 ± 13.2 (1 month to 60 years)
Incidence (paroxysms/year)	93.5 ± 154.9 (1/year up to several/day)
Maximal duration (hours)	7.8 ± 12.5 (0–72)
Frequency (bpm)	207.6 ± 39.0 (120–340)
Syncope (N, %)	42 (21.5%)
Resuscitation (N, %)	10 (5.1%)
Antiarrhythmic drugs per patent	1.9 ± 1.6 (0–6)
No medication (N, %)	45 (23.1%)

TABLE 2
CLINICAL DATA FOR 65 PATIENTS (38 MALES, 27 FEMALES, AGED 13–64 YRS. (38.9 ± 13.9)) INCLUDED IN THE FOLLOW-UP ANALYSIS OF SUCCESS RATE, RECURRENCE AND PERSONAL ASSESSMENT

Tachycardia	
Since (years)	17.1 ± 13.9 (1 month to 50 years)
Incidence (paroxysms/year)	133.7 ± 177.8 (1/year up to several/day)
Maximal duration (hours)	8.8 ± 12.5 (several minutes up to 72h)
Frequency (bpm)	214.5 ± 39.2 (140–340)
Syncope (N, %)	17 (26.2%)
Resuscitation (N, %)	4 (6.2%)
Antiarrhythmic drugs per patient	2.3 ± 1.7 (0–5)
No medication (N, %)	8 (12.5%)
ECG (preexcitation)	
Delta wave	43 (67.2%)
No delta wave	19 (29.7%)
Intermittent	2 (3.1%)

of the accessory pathway (unidirectional retrograde, anterograde, or bidirectional).

Follow-up of success rate, recurrence and personal assessment of the procedure by the patients

Clinical data for 65 patients included in the analysis of immediate success, long--term success, rate of recurrence of conduction through the accessory pathway, late block after the catheter ablation (delayed success) and personal follow-up are listed in Table 2. Long-term success was defined clinically as complete absence of previous symptoms and signs of paroxysmal tachycardia, along with the absence of delta wave in patients with overt preexcitation. Recurrence was defined as reappearance of the same symptoms and signs, and was, in each case, documented by a ECG recording of the recurrent tachycardia. The timing of recurrence was also recorded. The patients were questioned – using a standardized questionnaire, telephonically or in written form – about their personal assessment of the catheter ablation as a treatment method for their arrhythmia. Questions were asked concerning: (1) feasibility of ablation; (2) recommending the procedure to other patients with the same problem; (3) description of the energy delivery; (4) regaining the full overall quality of life after the intervention; (5) readiness to repeat the procedure, if necessary.

Statistics

Numerical data are listed as mean values ± standard deviation. The comparison between continuous variables was performed using a two-tailed t-test for unmatched variables. A p-value less than 0.05 was considered statistically significant.

Results

Learning curve

Procedure parameters for the ablation of all accessory pathways in 195 patients with a total of 234 procedures are depicted in Figure 2. Highly significant reduction was documented for all four procedure parameters in the second group of patients (51–100), with subsequent pla-

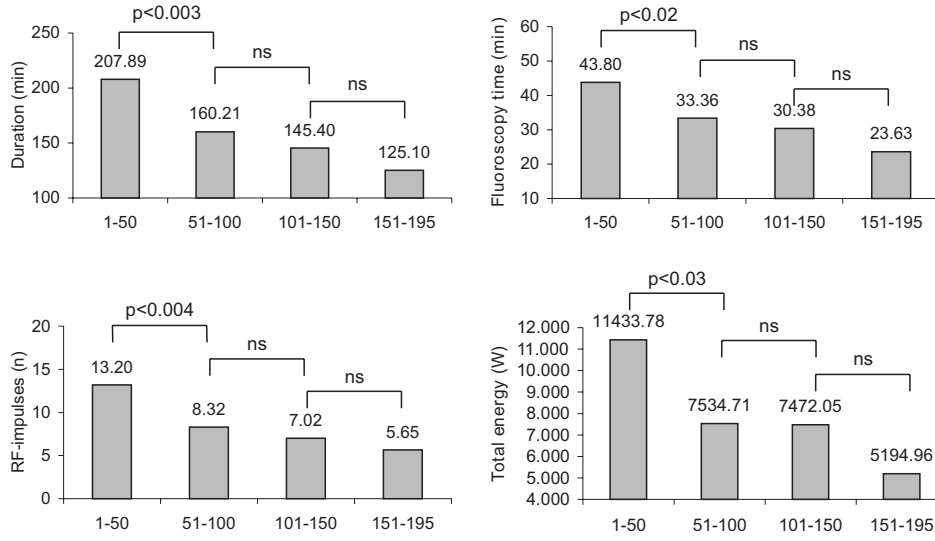

Fig. 2. Groups of cosecutive patients (1–50, 51–100, 101–150, 151–199), procedure duration, fluoroscopy time, number of RF-impulses per procedure and total energy delivered. Note the significant reduction for all parameters in the second patients' group (51–100).

teau of values after the 100th patient. Procedures were significantly shorter, with less radiation exposure, fewer RF-impulses needed for interruption of the accessory pathway and with reduced total energy delivered per procedure.

Concomitant atrial fibrillation and conduction properties of the accessory pathway

The incidence of atrial fibrillation was 81 out of 234 ablation procedures (34.6%). The comparison between patients with and without AF showed a trend for shorter procedure duration and fluoroscopy time, although these differences were not statistically significant (Table 3).

There were 61 (26. 1%) concealed accessory pathways, with retrograde only conduction. The procedure parameter analysis showed a tendency for longer ablation duration for these patients, however, without statistical significance (Table 4).

Follow-up data: immediate success rate, long-term success and recurrence

A total of 79 ablations were performed in 65 consecutive patients included in the follow-up. The data were obtained for all patients, with a mean follow-up period of 53.4±18.7 (36–74) months. In-hospital success rate was 82.3%. There were 5 (6.3%) patients with late conduction block (delayed success) after 2 to 5 days. None of the patients with late block had recurrence of conduction. The highest success rate was achieved for left free wall pathways (95.8%), followed by septal (80.0%) and right free wall pathways (52.4%).

Recurrence was observed in 5 patients (6.3%), 1 to 12 weeks after the procedure. 4 patients had a left free wall and 1 had right free wall pathway (recurrence rate of 8.3% and 4.8%, respectively). All patients with recurrence underwent a successful second ablation procedure and remained tachycardia-free.

TABLE 3
COMPARISON OF PROCEDURE PARAMETERS FOR PATIENTS WITH AND WITHOUT CONCOMITANT ATRIAL FIBRILLATION (AF)

AF	Ablations	Duration (min)	Fluoroscopy time (min)	RF-impulses	Total energy (W)
Yes	81	165.8 ± 83.4	34.8 ± 23.2	8.6 ± 7.7	7805.6 ± 8843.1
No	153	159.5 ± 87.9	32,5 ± 21.8	8.8 ± 8.5	8796.6 ± 9652.8
Significance	ns	ns	ns	ns	ns

TABLE 4
COMPARISON OF PROCEDURE PARAMETERS ACCORDING TO CONDUCTION PROPERTIES OF THE ACCESSORY PATHWAY

Conduction	Ablations	Duration (min)	Fluoroscopy time (min)	RF-impulses	Total energy (W)
Anterograde	11	169.5 ± 59.8	35.6 ± 19.8	6.5 ± 5.6	4698.0 ± 3995.6
Bidirectional	162	155.9 ± 90.1	33.6 ± 23.3	9.4 ± 9.0	9305.7 ± 10392.5
Retrograde	61	175.6 ± 78.8	32.3 ± 20.2	7.3 ± 6.2	6887.5 ± 6528.3
Significance	ns	ns	ns	ns	ns

TABLE 5
PARAMETERS OF SUCCESS (LONG-TERM SUCCESS AFTER FIRST ABLATION, TOTAL LONG-TERM SUCCESS) FOR ALL PATHWAYS AND ACCORDING TO ANATOMIC LOCATION

All accessory pathways			
	N	Long-term success (1st ablation)	Long-term success (total)
	65	51 (78.5%)	62 (95.4%)
According to pathway location			
Left free wall	42	36 (85.7%)	42 (100.0%)
Septal	9	8 (88.9%)	9 (100.0%)
Right free wall	14	7 (50.0%)	11 (78.6%)

Long-term success was achieved in 51 (78.5%) patients after the first and only ablation. This was increased to 62 (95.4%) after repeated procedures for recurrences (Table 5).

Follow-up data: personal assessment of the procedure by the patients

The data from the follow-up questionnaire showed high degree of acceptance and satisfaction with the treatment modality of catheter ablation (Table 6). Only one patient did not find the method feasible, because of long duration of the procedure. Majority of patients did perceive the RF-application; there were only 7 who did not feel the impulse delivery. 5 patients did not regain full overall quality of life, because they were not as much disturbed by their tachycardia before the

TABLE 6
PERSONAL ASSESSMENT OF CATHETER ABLATION IN THE PATIENT FOLLOW-UP

Question	Answer	N (%)
1. Do you find the procedure feasible / acceptable?	Yes:	64 (98.5%)
	No:	1 (1.5%)
2. Would you recommend ablation to other patients with the same tachycardia?	Yes:	65 (100.0%)
	No:	0 (0%)
3. How would you describe the impulse application / energy delivery (multiple options)?	Tingling:	29 (44.6%)
	Palpitation:	23 (35.4%)
	Pain:	15 (23.1%)
4. Did the ablation give you back your full quality of life?	Yes:	60 (92.3%)
	No:	5 (7.7%)
5. Would you consider repeated ablation, in case your tachycardia returns?	Yes:	62 (95.4%)
	No:	3 (4.6%)

procedure. Only three patients were not ready to repeat the ablation procedure, in case of tachycardia recurrence.

Discussion

The conception of the learning curve is of significant importance in modern medicine[9,10], especially in relation to the introduction of new and complex therapies, such as catheter ablation, into common clinical practice. Earlier studies were able to demonstrate various aspects of the effect of learning the ablation of accessory pathways, as well as other supraventricular arrhythmias. One study reported an increase in primary success rate from 55% for the first 20 patients to 88% for the next 33 patients[11]. An analysis of catheter ablation of accessory pathways in pediatric patients showed a calculated 90% level of experience after 240 cases[12]. An important aspect of completing the learning curve is the reduction of radiation exposure during fluoroscopy, as several studies had documented significant risks associated with longer duration of these kind of procedures[13,14]. The need for shorter procedures was highlighted by the fact that a fluoroscopy time exceeding 100 minutes increased the operator risk for malignancies by 200 times.

The results of our study documented a significant and constant reduction of all four relevant physical procedural parameters in the second group of consecutive patients (number 51–100). This implied the completion of the learning curve after 100 patients. Such results are also in conjunction with the requirements currently stated in the ACC/AHA guidelines for catheter ablation training, which demand 75 procedures during an education period of 12 months[15]. The learning effect includes growing experience with catheter manipulation and continuous education, coupled with technical improvements – such as refinement of regional potential analysis, new catheters and preformed introducers.

The 65 consecutive patients with follow-up had baseline clinical and electrophysiological characteristics, which were

typical for our entire patient population. Long-term success was achieved in 62 (95.4%) of patients, and varied with the location of the accessory pathway (100% for left free wall and septal pathways, vs. 78.6% for right free wall pathways). True recurrences were documented in 5 (6.3%) patients, with repeated tachycardia occurring after an interval longer than between the original paroxysms (1 to 12 weeks post ablation). These figures correspond with data found in the literature, with reported success rates between 86.1% and 99%, and recurrence rates of 7.8% to 12.3%[16–18]. In contrast to some results reported by other authors[19], we found that the late block of conduction, which occurred in 5 of our patients, was not associated with recurrence.

The answers from the follow-up questionnaire on acceptance and personal assessment of the procedure were consistently positive. Vast majority had found the treatment feasible and would have recommended it to others. As opposed to some data from the literature[2], majority of our patients did feel the energy delivery, although only 15 had described the moment as painful. The positive effect on the quality of life – an issue of significant importance as documented by various previous articles in a more general context[20] – had already been demonstrated for surgical interruption of accessory pathways[21]. This issue is important, because it involves an invasive procedure with, albeit very rare, potential complications, for treatment of elective patients with generally not life-threatening supraventricular arrhythmias, partially with low intensity of symptoms[22]. Our results showed that almost all patients found their overall quality of life to be significantly better after the catheter ablation. The main limitation of the latter results is the fact that this group of patients treated with catheter ablation had not been compared with a similar group on drug therapy only. However, such investigation does not seem likely, in view of the many significant and documented advantages offered by the ablation as an actual first-line treatment option.

In conclusion, the results of this study confirm the catheter ablation of accessory pathways – in particular after completion of the learning curve – as a low-risk and highly efficient treatment for symptomatic WPW-syndrome, with a high degree of patient-related acceptance.

REFERENCES

1. WOLFF, L., J. PARKINSON, P. D. WHITE, Am. Heart J., 5 (1930) 685. — 2. ZIPES, D. P., Specific arrhythmias: Diagnosis and treatment. Preexcitation syndrome. In: BRAUNWALD E.: Heart disease. (W. B. Saunders Company, Philadelphia, 2001). — 3. KUCK, K. H., M. SCHLÜTER, Dt. Ärztebl, 88 (1991) 1408. — 4. GALLAGHER, J. J., R. H. SVENSON, J. H. KASSEL, N. Engl. J. Med., 306 (1982) 194. — 5. SCHEINMAN, M. M, F. MORADY, D. S. HESS, J.A.M.A., 248 (1982) 851. — 6. JACKMAN, W. M., X. WANG, K. FRIDAY, C. A. ROMAN, K. P. MOULTON, K. J. BECKMAN, J. H. MCCLELLAND, N. TWIDALE, H. A. HAZLITT, M. I. PRIOR, P. D. MARGOLIS, J. D. CALAME, E. D. OVERHOLT, R. LAZAR, N. Engl. J. Med., 324 (1991) 1605. — 7. KUCK, K. H., M. SCHLÜTER, M. GEIGER, J. SIEBELS, W. DUCKECK, Lancet, 337 (1991) 1557. — 8. CALKINS, H., J. SOUSA, R. EL ATASSI, S. ROSENHECK, M. DE BUITLEIR, W. H. KOU, A. H. KADISH, J. J. LANGBERG, F. MORADY, N. Engl. J. Med., 324 (1991) 1612. — 9. GASTER, B., J. Am. Med. Ass., 270 (1993) 1280. — 10. HATLIE, M. J., J. Am. Med. Ass., 270 (1993) 1364. — 11. LEATHER, R. A., J. W. LEITCH, G. J. KLEIN, G. M.GUIRAUDON, R. YEE, Y. HO KIM, Am. J. Cardiol., 68 (1991) 1651. — 12. DANFORD, D. A., J. D. KUGLER, B. DEAL, C. CASE, R. A. FRIEDMAN, J. P. SAUL, M. J. SILKA, G. F. VAN HARE, Am. J. Cardiol., 75 (1995) 587. — 13. LINDSAY, B. D., J. O. EICHLING, H. D. AMBOS, M. E. CAIN, Am. J. Cardiol. 70 (1992) 218. — 14. CALKINS, H., L. NIKLASON, J. SOUSA, R. EL ATASSI, J. LANGBERG, F. MORADY, Circulation, 84 (1991) 2376. — 15. TRACY, J. Am. Coll. Cardiol., 36 (2000) 1725. — 16. LANGBERG, J. J., H. CALKINS, Y. N. KIM, J. SOUSA, R. EL ATASSI, A. LEON, M. BORGANELLI, S. J. KALBFLEISCH, F. MORADY, J.

Am. Coll. Cardiol., 19 (1992) 1588. — 17. LANGBERG, J. J., H. CALKINS, Y. N. KIM, J. SOUSA, R. EL ATASSI, A. LEON, M. BORGANELLI, S. J. KALBFLEISCH, F. MORADY, J. Am. Coll. Cardiol., 19 (1992) 1588. — 18. TIMMERMANS, C., J. L. R. M. SMEETS, L. M. RODRIGUEZ, G. ORETO, E. MEDINA, W. NOTHEIS, G. ROUCHOS, A. WEIDE, H. J. J. WELLENS, Br. Heart J., 72 (1994) 571. — 19. LEITCH, J. W., G. J. KLEIN, R. YEE, R. A. LEATHER, Y. H. KIM, Am. J. Cardiol., 70 (1992) 830. — 20. JUREŠA, V., D. IVANKOVIĆ, G. VULETIĆ, A. BABIĆ-BANASZAK, I. SRCEK, M. MASTILICA, A. BUDAK, Coll. Antropol., 24 (2000) 69. — 21. PRESSLEY, J. C., L. D. GERMAN, D. L. PACKER, J. Am. Coll. Cardiol., 2 (1988) 110. — 22. LAU, C. P., Y. T. TAI, P. W. H. LEE, Pace, 18 (1995) 424.

R. Bernat

Hospital for Cardiovascular Surgery and Cardiology »Magdalena«, Ljudevita Gaja 2, 49217 Krapinske Toplice, Croatia

DUGOROČNI REZULTATI I KRIVULJA UČENJA KOD RADIOFREKVENTNE ABLACIJE AKCESORNIH SNOPOVA

S A Ž E T A K

Radiofrekventna (RF) kateterska ablacija akcesornih snopova predstavlja intervencijsku metodu u modernoj kardiologiji, koja je postala terapija prvog izbora u liječenju pacijenata sa simptomatskim WPW sindromom. Cilj ove studije bila je analiza: (1) krivulje učenja za ablacijski postupak; (2) parametara postupka i uspješnosti; te (3) osobne procjene metode liječenja od strane pacijenata. U analizu krivulje učenja uključeno je 195 konzekutivnih pacijenata, kod kojih je učinjena ablacija između 1991. i 1996. godine. U anketu praćenja uključeno je 65 konzekutivnih bolesnika. Analiza parametara postupka pokazala je značajan napredak nakon 100 slučajeva, što ukazuje na završetak krivulje učenja u tom trenutku. Dugoročno praćenje pokazalo je visoku stopu uspješnosti za sve akcesorne snopove (95,4%). Svi parametri postupka ukazuju na viši stupanj teškoća kod desnostranih i septalnih snopova, pri čemu je stopa dugoročne uspješnosti najniža kod desnostranih snopova (78,6%). Anketa o osobnoj procjeni pokazala je visoki stupanj prihvaćenosti liječenja: 92,3% pacijenata opisalo je rezultat postupka kao značajno poboljšanje ukupne kvalitete života. Rezultati ove studije potvrđuju da je kateterska ablacija akcesornih snopova – posebno nakon završetka krivulje učenja – niskorizična i vrlo učinkovita metoda liječenja simptomatskog WPW sindroma, s visokim stupnjem prihvaćenosti od strane pacijenata.