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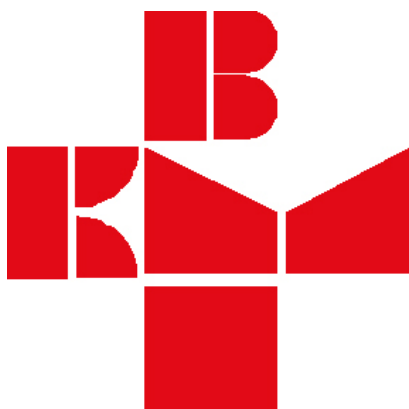
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# Learning Curve for Arteriovenous Fistula Creation

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## Abstract

**Objective:** Amount of time and number of procedures required in junior surgeon (JS) to achieve arteriovenous fistula (AVF) patency rate of surgeon with 20 years of experience. **Methods:** A single-center, retrospective, case-control study of AVF primary patency rate at 1 year postoperatively was observed among junior and experienced surgeon (ES) over a 4-year period. Fistula was created by terminolateral anastomosis in a fashion of continuous suture with nonabsorbable double-armed 7-0 monofilament. Maturation was grounded on the physical examination and fistula ultrasound 6 weeks postoperatively. **Results:** One hundred and twelve patients, 65% male and 35% female, were included in the study in 4 year period, 2015–2018. There were 51% radiocephalic and 49% brachiocephalic fistulas constructed by JS. Patency rate for JS was 66% overall, combining 64% for radiocephalic and 67% for brachiocephalic, compared to ESs 79%, performing only brachiocephalic fistulas. In the first 3 years, patency rate was 63%, 60%, and 66%, while significant improvement was accomplished in the the 4<sup>th</sup> year with patency rate of 75%. Average time for hemodialysis initiation was 88 days postoperatively. **Conclusions:** Three years and approximately 60 procedures are required for JS to produce results comparable to ES in creation of AVF.

**Keywords:** Arteriovenous fistula patency, dialysis access, end-stage renal disease, hemodialysis, learning curve

## INTRODUCTION

Chronic kidney disease is global disease with a prevalence of 11%–13%.<sup>[1]</sup> In Croatia, according to renal replacement therapy registry, 4000 patients have the end-stage renal disease. In Croatia, most of the patients (94%) who are on dialysis are on hemodialysis (HD).<sup>[2]</sup>

The arteriovenous fistula (AVF) is still the best option regarding the vascular access for patients on HD.<sup>[3]</sup> AVF is favored in every case where there is sufficient time and patient conditions allow formation of AVF. As compared to an arteriovenous graft, it has lower rate of long-term adverse effects such as thrombosis, loss of primary patency, as well as need for vascular interventions. As compared to tunneled dialysis catheter, fistula has better patency and lower infection rates.<sup>[4-6]</sup>

Physical examination directed on vascular anatomy is crucial for AVF creation. Therefore, preoperative ultrasound is recommended only in high-risk AVF failure patients in which vessel mapping could be helpful, for example, elderly, small pediatric patients, peripheral vascular disease patients, coronary artery disease patients, and peripheral vessel damage patients.<sup>[7-9]</sup>

While currently there is no minimum diameter limit regarding AVF creation, vessels <2 mm in diameter should be well thought-out before creating AVF on such a small vessel because of potential poor flow or lack of distensibility.<sup>[10,11]</sup> However, there are several recommendations involving minimal arterial and venous diameter averring 2 mm in the forearm and 3 mm in the upper arm.<sup>[7,12]</sup>

According to fistula first recommendation, the AVF should be the first choice for vascular access. The set goal was to have at least 66% patients on HD through AVF.<sup>[13]</sup> New studies showed that this system has its flaws because heterogeneity between patients and that maybe patient based approach could have better results.<sup>[14-16]</sup>

In our hospital, around 40% patients start HD with AVF.

The one of the main reasons for low percentage of AVF in Croatia is low number of surgeons who are performing AVF operations due to retirement, emigration, low interest, and poor structural personnel training.<sup>[17]</sup>

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The goal of the study is to determine how long is the learning curve for a successful formation of AVF.

## METHODS

In our hospital, only one experienced surgeon (ES) performed the AVF operations. Four years ago, a junior surgeon (JS) joined the program. All patients were physically examined (pulsations of brachial, radial, and ulnar arteries with performing Allen’s maneuver). Preoperative ultrasound with mapping was performed in selected patients with the cutoff for performing AVF on the upper forearm was diameter smaller than 2 mm for the radial artery or 2.5 mm for cephalic vein in the forearm.

Terminolateral anastomosis was performed using continuous suture with nonabsorbable double-armed 7-0 monofilament. Maturation was determined on the physical examination with or without additional postoperative ultrasound 6 weeks after the procedure.

The end point of the study was the patency of AVF 1 year after the operation.

Each year of JS’s experience was analyzed separately. Latest year of ES was taken as control group.

The study was approved by the Hospital Ethics Committee.

Each participant signed an informed consent to participate in the study.

## RESULTS

One hundred and twelve consecutive patients in need for AVF were enrolled in this study between 2015 and 2018. Out of the 112 patients, 73 were male and 39 were female. The median patient’s age was 63.0 (47.8; 70.8) years. Forty-nine patients (43.4%) were already on HD via catheter before the procedure. Average time for the use of AVF to perform HD was  $88.3 \pm 10.7$  days.

Similar percentage of radiocephalic (51%) and brachiocephalic (49%) AVF was observed.

When demographic data were compared, there was no significant difference between ES and JS except in the number of patients who had catheter placed before procedure [Table 1].

The underlying diseases in our patients included diabetes mellitus (34%), hypertension (22%), and glomerulonephritis (20%). Other diseases included polycystic kidney, uropathy, pyelonephritis, and lupus erythematosus.

Overall, 1-year patency rate was 79% for ES and 66% for JS. The overall patency of radiocephalic and brachiocephalic AVF was 64% and 67% for JS. ES performed only brachiocephalic AVF. When analyzed year by year, significant improvement was seen for JS by the 4<sup>th</sup> year. During the first 3 years, the overall patency rate for JS was 63%, 60%, and 66%. In the 4<sup>th</sup> year, the patency rate became similar to ES with 75% patency rate [Figure 1].

At 4<sup>th</sup> year, JS performed more than 25 procedures per year [Table 2].

## DISCUSSION

In this study, average time from the construction of AVF to its use for HD was 3 months. Unfortunately, many patients were using catheter as vascular access for dialysis in meantime. Among the many reasons for late construction of AVF (such as patient’s unacceptance of HD, late referral for fistula construction) one of the major reasons in Republic of Croatia is shortage of surgeons who perform the procedure.

**Table 1: Demographic data experienced surgeon versus junior surgeon**

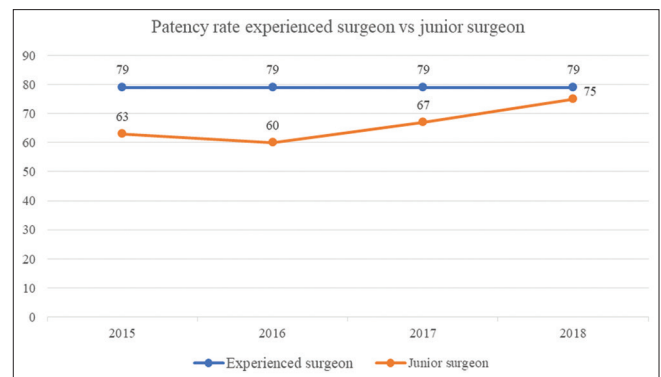
	ES	JS	P
Patient age (median; years)	64.00 (48.50; 73.75)	62.00 (47.75; 70.00)	NS
Patient gender (male/female)	14/10	59/29	NS
Catheter before AVF (yes/no)	14/10	39/49	0.02
Days to HD via AVF	77.00±20.08	92.46±12.75	NS

AVF: Arteriovenous fistula, HD: Hemodialysis, ES: Experienced surgeon, NS: Non significant, JS: Junior surgeon

**Table 2: Number of procedures per year (junior surgeon/ experienced surgeon)**

Year	Successful HD via AVF		Total
	No	Yes	
2015			
JS	7	12	19
2016			
JS	8	12	20
2017			
JS	7	14	21
2018			
JS	7	21	28
ES	5	19	24
Total	34	78	112

AVF: Arteriovenous fistula, HD: Hemodialysis, ES: Experienced surgeon, JS: Junior surgeon



**Figure 1: Patency rate experienced surgeon versus junior surgeon**

Therefore, we undertook this study to evaluate how long does the training take for a surgeon to become successful in performing AVF with high patency rate. In this study, combined primary patency rate of JS and ES after the 1<sup>st</sup> year was 70%. The control group in this study was patients operated on by a vascular surgeon with 20 years of experience in the construction of AVF. The JS joined the fistula program just after residency where he had received standard surgical education including construction of AVF. The average number of procedures by the JS in first 3 years was 20 per year. In the 4<sup>th</sup> year, the number of procedures became similar to ES. This is consisted with the data from the Dialysis Outcomes and Practice Patterns Study from 12 international countries that showed decrease of primary AVF failure for 34% for surgeons who created  $\geq 25$  AVF.<sup>[18]</sup> During the first 3 years, the patency rate for JS was 63% ( $P = 0.013$ ), 60% ( $P = 0.004$ ), and 66% ( $P = 0.056$ ). In the 4<sup>th</sup> year, patency rate of 75% became similar with ES ( $P = 0.5$ ) [Figure 2].

Patency rates differ from study to study. In Kalman *et al.*'s study, the primary success rate of 466 patients for 2 years was about 54%  $\pm$  4%.<sup>[19]</sup> In Kazemzadeh *et al.*'s study, the primary patency rate for 245 patients after 2 years was 65%.<sup>[20]</sup> In the study by Lee *et al.* that consisted of 7301 patients, primary patency was 56% at 2 years.<sup>[21]</sup> Ates *et al.* reported primary patency of 71% and 87.7% for radiocephalic and brachiocephalic AVF at 2 years.<sup>[22]</sup>

In the present study, the patient age, smoking or cause of ESDR, were not risk factors for patency of AVF which is similar to other studies.<sup>[20]</sup>

Main drawbacks of this study are that it is single-center study, it included only two surgeons who perform AVF's creation and that JS performed both radial/brachial cephalic AVF's, while ES performed only brachial cephalic AVF's.

## CONCLUSIONS

It took 3 years and 60 procedures for a JS to become nearly as skilled as ES. This should be taken as serious calculation when planning for structural personnel training.

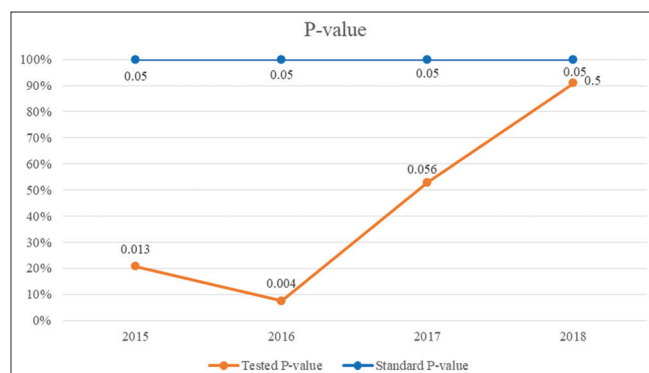


Figure 2: P value

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## Conflicts of interest

There are no conflicts of interest.

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