

Life-saving vascular access in vascular capital exhaustion: single center experience in intra-atrial catheters for hemodialysis

Acesso vascular *life-saving* na exaustão do capital vascular: experiência de um centro com cateteres intra-auriculares para hemodiálise

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ABSTRACT

Introduction: Intra-atrial catheter (IAC) placement through an open surgical approach has emerged as a life-saving technique in hemodialysis (HD) patients with vascular access exhaustion. **Objective:** To assess the complications of IAC placement, as well as patient and vascular access survival after this procedure. **Methods:** The authors retrospectively analyzed all seven patients with vascular capital exhaustion, without immediate alternative renal replacement therapy (RRT), who underwent IAC placement between January 2004 and December 2015 at a single center. **Results:** Seven patients were submitted to twelve IAC placements. Bleeding (6/7) and infections (3/7) were the main complications in the early postoperative period. Two (2/7, 29%) patients died from early complications and 5/7 were discharged with a properly functioning IAC. The most frequent late complication was catheter accidental dislodgement in all remaining five patients, followed by catheter thrombosis and catheter-related infections in the same proportion (2/5). During follow-up, two of five patients died from vascular accesses complications. After IAC failure, one patient was transferred to peritoneal dialysis and a kidney transplant was performed in the other. Only one patient remains on HD after the third IAC, with a survival of 50 months. The mean patient survival after IAC placement was 19 ± 25 (0-60) months and the mean IAC patency was 8 ± 11 (0-34) months. **Conclusion:** Placing an IAC to perform HD is associated to significant risks and high mortality. However, when alternative RRT are exhausted, or as a bridge to others modalities, this option should be considered.

Keywords: central venous catheters; chronic kidney failure; vascular surgical procedures.

RESUMO

Introdução: A colocação de cateteres intra-auriculares (IAC) tem surgido como uma técnica *life-saving* nos doentes em hemodiálise (HD) com exaustão de acessos vasculares. **Objetivo:** Analisar as complicações decorrentes da colocação de IAC, assim como a sobrevivência dos doentes e do acessos vascular após este procedimento. **Métodos:** Os autores analisaram retrospectivamente sete doentes com exaustão de acessos vasculares para HD, sem alternativa imediata de terapêutica substitutiva renal, submetidos a colocação de IAC entre Janeiro de 2004 e Dezembro de 2015. **Resultados:** Os sete doentes foram submetidos à colocação de doze IAC. A hemorragia (6/7) e as infeções (3/7) foram as principais complicações no pós-operatório imediato. Dois (2/7, 29%) doentes faleceram por complicações precoces e 5/7 tiveram alta com cateter funcional. A complicação tardia mais frequente foi a exteriorização acidental do cateter em todos os doentes, seguida da trombose e infeção relacionada com o cateter, na mesma proporção (2/5). Durante o seguimento, dois dos cinco doentes faleceram por complicações associadas com o acesso vascular. Após a falência do IAC, um doente foi transferido para diálise peritoneal e outro foi submetido a transplantação renal. Apenas um doente permanece em HD após o terceiro IAC, com uma sobrevivência de 50 meses. A sobrevivência média dos doentes após colocação de IAC foi de 19 ± 25 (0-60) meses e a patência média do IAC foi de 8 ± 11 (0-34) meses. **Conclusão:** A colocação de um IAC para HD esteve associado a riscos significativos e mortalidade elevada. Contudo, quando as terapêuticas de substituição renal alternativas estão esgotadas, ou como uma ponte para outras modalidades, esta opção deve ser considerada.

Palavras-chave: cateteres venosos centrais; falência renal crônica; procedimentos cirúrgicos vasculares.

INTRODUCTION

Maintaining a functioning vascular access is critical for patients on hemodialysis (HD). With an increasing number both in patients on HD as in their survival, the number of patients with exhaustion of traditional venous accesses is rising. Multiple venous access failure in patients on HD is one of the greatest and most dramatic challenges that nephrologists and patients have to face.

In patients with exhaustion of conventional vascular accesses, who are not candidates to peritoneal dialysis (PD) or renal transplantation, or that are awaiting the latter, the placement of intravascular catheters in non-traditional locations¹⁻⁴ has allowed these patients to remain alive and on HD. In our center, intra-atrial catheter (IAC) placement has emerged as a life-saving option in these situations.

The purposes of this study were to evaluate the outcome of patients with multiple vascular access failure submitted to IAC placement, as well as complications related to this procedure.

METHODS

The authors retrospectively reviewed the medical records of seven patients who had IAC placement between January 2004 and December 2015 at Hospital de Santa Maria in Lisbon, Portugal. Patients undergoing this procedure had a history of multiple vascular access failure and central venous occlusion or stenosis unresolved by angiography, which made impossible the placement of a central HD catheter.

We collected demographic data, as well as information concerning co-morbidities, time on and possibility of an alternative renal replacement therapy (RRT). Patient demographic and clinical characteristics are described in Table 1. Outcome was evaluated as patient survival and IAC patency. Data regarding early and late complications from the IAC insertion procedure were also collected. Early complications were considered those that occurred during hospitalization of the first IAC (31 ± 15 days). The complications after discharge of this hospitalization were registered as late complications.

SURGICAL TECHNIQUE

Permanent IAC were placed by the same cardiothoracic surgeon and the surgical technique has been modified in order to decrease complications and improve

results over the reviewed period. From January 2004 to December 2010, this procedure was done using median sternotomy with right partial pericardiectomy, catheter tunneling, through the right anterior chest wall, using the Seldinger technique, placement of the tip of the catheter in the right atrium and fixation with double purse string suture (Figure 1).

Since then, IAC insertion was done using less invasive techniques, through right anterior mini-thoracotomy or median mini-sternotomy, and the approach using median sternotomy was only resorted if IAC complications developed. IAC placed were double lumen catheters with a cuff that were in subcutaneous location in the chest wall (Figure 2).

RESULTS

EARLY COMPLICATIONS

In the early postoperative period, bleeding and infections were the main complications reported in 6/7 and 3/7 cases, respectively. Postoperative chest bleeding occurred in patients 1, 2, 3, 4, 5 and 7, was estimated from 500 to 1600cc, and in all cases was resolved without surgical intervention. In patients 1 and 2 sepsis without agent identification or infectious source was recorded. Patient 5 registered an nosocomial pneumonia.

Two patients (29%) died from early complications. Patient 1 died on the first postoperative day from septic and hemorrhagic shock. Patient 5 died on the eleventh postoperative day from nosocomial pneumonia.

LATE COMPLICATIONS

Five patients (patients 2, 3, 4, 6 and 7) were discharged with a properly functioning IAC.

The most frequent complication after discharge was catheter dislodgement with cuff exposure, which ultimately occurred in all patients, on average at 9 ± 9 (1-24) months after procedure. Another IAC was placed whenever possible, since the severity of the vascular situation remained the same in all patients. It was considered that there were no clinical conditions for the placement of a new IAC in patients 3 and 4. The first died from retroperitoneal hematoma when attempting to place a femoral vein catheter to perform hemodialysis.

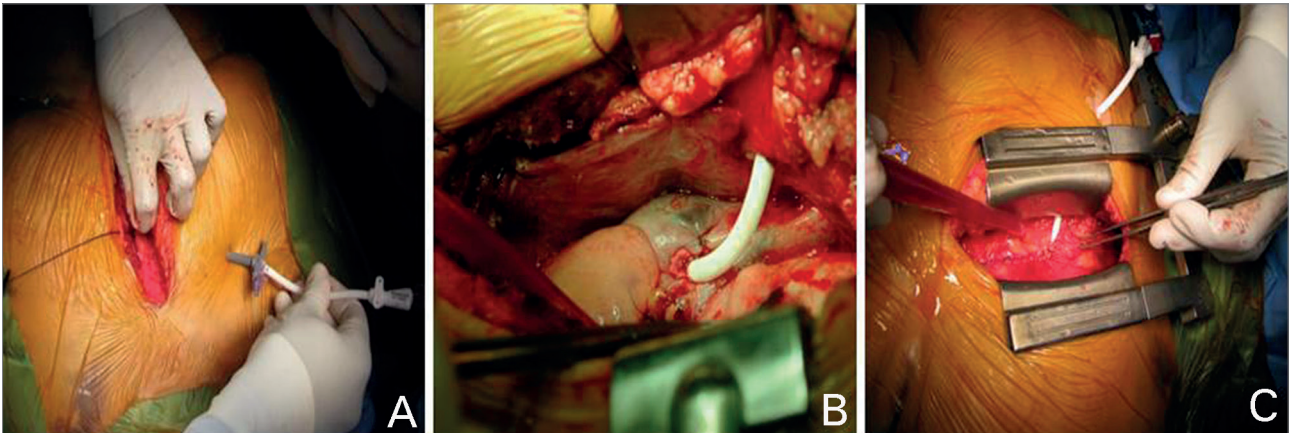
Patient 4 was transferred to PD with family support. In the remaining patients (patients 2, 6 and 7) a new IAC was placed. Patient 2 had two

TABLE 1 DEMOGRAPHIC AND CLINICAL CHARACTERISTICS OF PATIENTS

	Age (y)	Gender	Race	CKD etiology	CCI	First RRT	Time on RRT (m)	Alternative RRT	
								Peritoneal dialysis	Transplant
mean (SD)	66 (13)				5.6 (1.7)		76 (47)		
P1	76	F	C	nephrolithiasis	6	HD	28	EF - pericatheter leak	CI - age/IVC thrombosis
P2	54	M	C	hypertension	5	HD	17	CI - obesity	CI - IVC thrombosis
P3	65	F	C	AD PKD	7	HD	149	LF - colon laceration	CI - IVC thrombosis
P4	74	M	C	chronic interstitial nephritis	6	HD	111	CI - lack of autonomy	CI - age/neoplasia
P5	69	F	C	diabetic nephropathy	7	HD	50	CI - lack of autonomy	CI - IVC thrombosis
P6	81	F	C	hypertension	6	HD	96	EF - IP adhesions	CI - age/IVC thrombosis
P7	44	F	B	hypertension	2	HD	80	EF - pleural leak	urgent transplant

AD PKD: autosomal dominant polycystic kidney disease; B: black; C: Caucasian; CI: contraindication; CCI: Charlson comorbidity index; CKD: chronic kidney disease; EF: early failure; F: Female; HD: hemodialysis; IP: intra-peritoneal; IVC: inferior vena cava; LF: late failure; M: male; m: months; RRT: renal replacement therapy; SD: standard deviation; y: years.

Figure 1. Surgical technique of intra-atrial catheter insertion. A: Catheter placement using Seldinger technique. B: Fixation with a double purse string suture. C: Sternotomy closure.



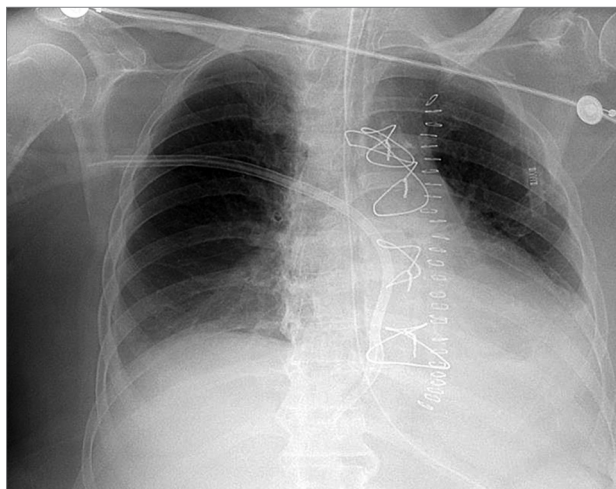
IAC, while patients 6 and 7 were submitted to this procedure three times. In patient 6, after the third IAC placement, an improved surgical technique and a special attention to the fixation of the catheter to the skin successfully prevented its repeated dislodgement.

Catheter thrombosis was registered in 2/5 patients (patients 2 and 7). In patient 2 the thrombosis was suspected at the fourth day after IAC replacement. Recombinant tissue plasminogen activator was administered into each port of the double-lumen catheter, with the exact volume to fill in the catheter

ports, a procedure that was complicated by pericardial tamponade and death. In patient 7, the attempt to perform intracatheter thrombolysis with recombinant tissue plasminogen activator with the same technique was unsuccessful and uneventful.

Catheter-related infections were reported in 2/5 patients. Patient 2 developed an exit site infection of the first IAC, which was resolved with local and systemic antibiotics. After the third IAC, patient 7 presented a deep thoracic wound infection due to *Serratia marcescens*, with sepsis, which was treated

Figure 2. Post-procedure chest radiograph showing direct intra-atrial catheter in place.



with systemic antibiotherapy, surgical drainage and vacuotherapy.

IAC PATENCY AND PATIENT SURVIVAL

Excluding the two patients who died in the early postoperative period of the first procedure, the mean patency of the first IAC was 9 ± 9 (1-24) months. The seven patients were submitted to twelve IAC placements between January 2004 and December 2015. Globally, the mean IAC patency was 8 ± 11 (0-34) months.

During follow-up, four of seven patients died after surgery (two patients after the first IAC placement, the other two after surgery of the second IAC). The causes of death were: hemorrhagic and septic shock in patient 1; pericardic tamponade in patient 2; retroperitoneal

hematoma in patient 3; and nosocomial pneumonia in patient 5. After IAC failure, patient 4 was transferred to PD with family support. Patient 6 remains on HD after the third intra-atrial catheter, with a survival of 50 months to date.

After several surgical wound infectious complications and IAC dysfunction, patient 7 underwent implantation of a *Hemodialysis Reliable Outflow (HeRO) Graft*, which was followed by an urgent deceased donor kidney transplant due to medical conditions, three weeks later. This device was not the first option for this patient because it was inaccessible in Portugal, was the first placed in our country, and because the jugular veins occlusion prevented their placement in accordance with the technique described in clinical.

The mean time survival after IAC placement was 19 ± 25 (0-60) months. Patient follow-up is described in Table 2.

DISCUSSION

The insertion of an intravascular catheter directly into the right atrium is a common practice in pediatric cardiac surgery.⁵ In this age group, small bore catheters are used temporarily, removed by simple traction, and are not associated with significant complication.⁵ The procedure is not technically demanding and its complications are related mainly to the patient's general conditions.

Prolonged use of an IAC to perform HD was first described by Chavanon *et al.*⁶ in 1999. Since then, there have been several case reports,⁷⁻⁹ and three small

TABLE 2 PATIENTS FOLLOW-UP

	First IAC	First IAC failure (months)	Second IAC	Second IAC failure (months)	Third IAC	Third IAC failure (months)
P1	30-04-2004 (death)					
P2	30-01-2009	1,2	07-03-2009 (death)			
P3	26-03-2010	3,3	No (death)			
P4	05-02-2011	23,9	No (peritoneal dialysis)			
P5	10-09-2011 (death)					
P6	01-12-2011	9,8	20-09-2012	5,9	15-03-2013	No (34 months until December 2015)
P7	16-07-2014	6,7	01-02-2015	3	2-05-2015	2,0 (Hero graft)

IAC: Intra-atrial catheter.

series were published.¹⁰⁻¹² The experience with these catheters in HD is limited and, although their use remains restricted to life-saving situations of multiple venous access failure, with no other possibility of alternative RRT, an analysis of survival on HD with IAC and associated complications is essential to consider the best therapeutic options.

The authors describe a series of patients who had IAC placement to perform HD. These patients had multiple vascular access failure and central venous occlusion or stenosis unresolved by angioplasty, which made the insertion of an HD catheter into a central vein impossible. The inferior vena cava (IVC) catheterization, an option described by some centres,¹³ was not possible in most of these patients. Only one of them had IVC patency, however, the authors experience in this technique was poor and results published in the literature are limited, which determined the option for an IAC in all situations.

In the series presented, the authors found a female preponderance (5/7, 71%). In the largest series described, most patients were also female (17/27; 63%).¹² This gender preponderance is probably related to the lower vascular access survival reported for women.¹⁴

Bleeding and infectious situations were the main complications identified in the early postoperative period, which culminated in the death of two patients. The postoperative mortality rate (29%) in this cohort is far from those of 7% and 13% reported in other series.^{10,12} The causes of death were also different from those previously reported - cardiovascular (acute myocardial infarction and ventricular fibrillation¹² and metabolic.¹⁰

The mean age of this population, well above of previously published series (66 years *versus* 49, 54 and 59 years),¹⁰⁻¹² may justify these poorer results. Patients who died in the early postoperative period were 76 and 69 years old, respectively, and had several comorbidities, reflected by their high Charlson comorbidity index, 6 and 7, respectively.

With an intra-cardiac approach, infections, mechanical dysfunction and catheter thrombosis, which are the main causes of traditional HD catheter failure,¹⁵ remain as causes of morbidity related to the IAC. Catheter-related infections, one of the major concerns with HD catheters, are infrequent in the IAC, comparing to other catheters locations.

In their series of 27 patients, Oguz *et al.*¹² did not report any bacteremia situation related to vascular access. In the presented series, two episodes of IAC-related infection have been reported, only one of them with systemic repercussion. As suggested by other authors,¹² the reduced bacteremia may be associated with limited follow-up, careful surgical techniques and aseptic care in the manipulation of IAC for HD.

Spontaneous accidental dislodgement, which is rarely described in traditional HD catheters, occurred in all patients of this cohort. Oguz *et al.*¹² describe IAC dislodgement as the most frequent complication of this technique, despite a significantly lower incidence than reported here (100% *versus* 15%). Spontaneous dislodgement may be related to problems with the creation of an adequate subcutaneous tunnel or inadequate choice of catheter size. Since its replacement requires a new surgical approach, extreme care in choosing the appropriate catheter size, the appropriate surgical technique and in handling these catheters is critical to prevent patient's exposure to this additional risk.

In our series, three re-interventions were performed in two patients; in one of them, after the third IAC placement, surgical technique has been improved and special attention to the fixation of the catheter to the skin successfully preventing its repeated displacement since then.

Catheter thrombosis occurred in two of the patients in our series; however, the administration of intraluminal thrombolytic was unsuccessful in solving this problem. In one of these patients, this procedure was performed on the fourth post-operative day and was complicated by pericardial tamponade and death.

In our series, the mean patient survival after IAC placement was 19 months and the longest survival on HD with an IAC was 50 months, with follow-up extended to the present date. This confirms the results of previous publications, in which the IAC placement via thoracotomy was considered a viable alternative in patients with vascular access exhaustion. Agrawal *et al.*¹¹ reported the case with the longest survival time on HD with an IAC.

In this patient, in whom a new kidney transplant was technically impossible to perform and for whom PD capacity was exhausted, the insertion of an IAC was able to extend his survival for 76 months. After several catheter-related complications, the patient

died from a situation not related to the vascular access. In other cases,^{6,11} IAC insertion was a bridge to kidney transplantation, as was one of our patients.

Placing an IAC to perform HD is accompanied by significant risks and high mortality, so all possibilities for other RRT must be exhausted. The patient's age, frequently seen as a potentially limiting feature, was not a problem in our series. In fact, in our review, we describe cases in which the survival of this type of access was notorious, even in elderly patients, in which the possibility of a new IAC placement was viable.

Therefore, when an alternative RRT is impossible, or when required to act as a bridge to other modalities, this option should be considered. At our department, we believe that technical improvement will be needed to achieve optimal results, as well as optimal catheter handling, particularly regarding the reduction of the main complication on this review, the spontaneous dislodgement.

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