Intra-access Pressure: Do We Really Need to Know? A Critical Review

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Abstract:

Arteriovenous (AV) fistula and AV graft are considered superior to venous catheter access, remarkable success has been achieved in increasing prevalence of AV fistula. However, vascular access complications are common and result in increased hospitalization, mortality and expense. Guidelines suggest various methods to maintain patency of vascular access. Amongst these various methods used for vascular access monitoring and surveillance, intra-access pressure (P_{IA}) is a simple tool which can be helpful in early detection and management of stenosis in vascular access. Intra-access pressure, although a very simple and quick method of vascular access evaluation, has a low diagnostic accuracy in prediction of vascular access stenosis as compared to other methods of access surveillance. We discuss here the physiology, methodology and the utility of intra-access pressure.

Key Words: *Static intra-access pressure ratio, vascular access blood flow, mean arterial pressure.*

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PJKD 2020;01 :189-192

Introduction:

Vascular access has a critical importance in the dialysis patient's life. Currently, arteriovenous fistula (AVF) and arteriovenous graft (AVG) are common forms of permanent dialysis vascular access. The maintenance of vascular access is a challenging task. The vascular accesses are prone to thrombosis, infection and other complications which can decrease the adequacy of dialysis treatment leading to under dialysis and increased hospitalizations[1]. Insufficient flow by vascular access stenosis cause inadequate dialysis or access thrombosis if not identified and treated in a timely fashion.

There is a significant failure rate for autogenous AVFs, estimated at 0.2 events per patient/year. For AVG, this increases to 0.8–1.0 events per patient/year. In a recent meta-analysis, the primary failure rate for autogenous wrist AVF was 15.3%. Primary and secondary 1-year patency rates were 62.5 and 66.0% respectively [2].

Regular monitoring and surveillance of arteriovenous (AV) access is necessary to prevent complications. Angiography is the gold standard modality for identification of stenotic vascular lesions, but it is expensive and invasive. Radiocontrast media may reduce residual renal function in hemodialysis (HD) patients. Therefore, several non-invasive assessment tools were developed to observe the flow[3]. Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines enlist some techniques for monitoring and surveillance of AV access, these include physical examination of access, duplex ultrasound, blood flow monitoring, intra-access static pressure, and access recirculation[4]. K/DOQI guidelines recommends intra-access flow (Qa) measurement as the preferred vascular access surveillance method, followed by static intra-access pressure ratio (SIAPR), which is static intra-access pressure normalized to mean arterial pressure (MAP)[5].

Intra-access Pressure (P_{IA}):

Intra-access pressure measurement can be dynamic or static. Dynamic measurements of venous intra-access pressure (P_{DC}) at pump blood flow rates of 200 ml/min is commonly used screening tools for detecting venous stenosis in vascular access in most of hemodialysis units[6]. The impeding blood flow prior to stenotic lesion results in elevation of intra-access pressure, this increase in P_{IA} is reflected as increase in drip chamber pressure. However, at high blood flow rate i.e 200 ml/min, high pressure recorded at the venous drip chamber is due to flow resistance through the venous needle and not by P_{IA}. Dynamic measurements of pressure are susceptible to errors created by inconsistencies in blood pump speed and variations in needle size and needle placement[7]. Therefore, static intra-access pressure (SIAPR) normalized by mean arterial pressure (MAP) is more relevant to vascular access surveillance as compared to venous pressure from dialysis machine (VP_{DM}). Sequential direct monitoring of P_{IA} and the ratio of P_{IA}/MAP has a high level of sensitivity and specificity as a screening tool for venous outlet stenosis in patients with AVGs[8]. SIAPR values lower than 0.13 and higher than 0.43 were considered to be indicators of the presence of stenosis[9,10].

Techniques of Measurement of SIAPR:

Besarab et al[11] measured intra-access pressure using an "in line" high-flow stopcock with no restriction to flow (<2 torr at flows of 500 ml/min) inserted between the venous return needle and the dialyzer venous return blood line prior to the initiation of dialysis. This high flow stopcock is connected via a three-way stopcock to a pressure transducer and monitor, Figure 1. Transducer pressure was measured by a patient monitor (Hewlett Packard, King of Prussia, PA, USA) both at usual dialyzer blood flow (range 275 to 375 mI/mm) and at zero dialyzer blood flow (VP0) within the first hour of dialysis. Pressure at the usual flow rates reflected the intra-access pressure (VP0) plus pressure created by flow through the venous circuit and venous needle. To measure VP0, the blood pump was stopped and a stable reading for VP0 was achieved within 40 seconds. The systemic blood pressure (BP) was simultaneously measured.

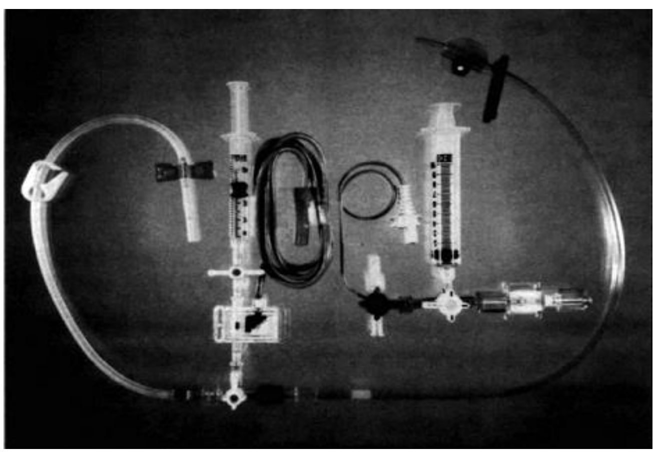

Fig. 1: This picture is taken from Besarab et al: Vascular intra -access pressure and thrombosis.[11]

Figure 1 shows the stopcock transducer system for measurement of SIAPR. [11] It is placed before the venous return needle and after the dialyzer venous return blood line prior to start of the dialysis.

Intra-access pressure can also be measured other than this above-mentioned conventional method by using pressure transducer applied between venous needle and venous drip chamber. Conventional P_{IA} was measured by measuring P_{DC} and ΔP_H (hydrostatic pressure difference). ΔP_H is the difference of transducer pressure and drip chamber pressure, at zero blood flow P_T is higher than P_{DC}, while it is vice versa at high blood flow. The variation in ΔP_H among different dialysis machines and centers was related to a simply measured parameter, the height difference between the drip chamber and the armrest of the dialysis chair (ΔH) as shown in **Figure 2**. So, equivalent intra-access pressure $_{EQ}P_{IA}$ can be calculated simply by measuring P_{DC} at zero blood flow , holding ultrafiltration to avoid changes in P_{DC} and measuring a height difference between access site and top of venous drip chamber, $_{EQ}P_{IA} = P_{DC} + \Delta P_H$. Factors affecting $_{EQ}P_{IA}$ are differences in ΔH and MAP. No significant differences between P_{IA} / MAP and $_{EQ}P_{IA}$/MAP ratios (paired t test) were noted for either native or graft access types at any center. Correlation between ${}_{EQ}P_{IA}$/MAP and P_{IA} / MAP was excellent[12].

Figure 2. Height measurment (Δ H) from the drip chamber level to the AVF level i.e. the level of the arm rest

Utility of Static Intra-access Pressure Ratio (SIAPR) in detection of Access Stenosis:

Stenosis is almost always a prerequisite for access thrombosis, Pre-emptive detection and correction of stenosis should reduce likelihood of access thrombosis. SIAPR is often measured with access flow measurement Q_a, as access flow measurement is preferred method of access monitoring by KDOQI. Smits et al[13] reported that standardized monitoring of either venous pressure, access flow or the combination of both with subsequent corrective intervention can reduce thrombosis rate in grafts. The K/DOQI, SIAPR protocol uses referral criteria based on trend analysis, as well as absolute SIAPR thresholds. For trend analysis the K/DOQI-recommended threshold for referral of > 0.25 over baseline[14].

Intra-access pressure is a surrogate for Qa (i.e. that high SIAPR correlates with low Qa associated with hemodynamically significant outflow stenosis)[12]. The SIAPR method is based on the presumption that high SIAPR is an indirect indicator of low blood flow (Qa) associated with hemodynamically significant stenosis[8,12], but most of the studies did not find any correlation between SIAPR and $Q_{a,}$ as SIAPR cannot discriminate between high and low blood flow[15,16]. Spergel et al[14], claimed that the authors recognize and acknowledge that SIAPR can identify a subset of AVGs with outflow stenosis because outflow stenosis is one cause of high SIAPR, However, a surveillance tool must have sufficient discriminatory power to minimize false-positive referrals. The above discussion explicit that SIAPR at any threshold cannot discriminate between an access with clinically significant stenosis and a well-functioning access with high Qa. Besarab et al[11], concluded that direct measurement of SIAPR is a simple, accurate technique for the assessment of vascular access hemodynamics and value of > 0.4 is a sensitive and specific indicator of venous outlet stenosis and a strong indication for angiography.

SIAPR has limitations in detecting inflow stenosis, this is based on the fact that some stenosis are located in the arterial flow tract that is upstream of the venous needle. These lesions increase resistance and reduce Qa without increasing P_{IA}, possibly even decreasing P_{IA}. Several studies have indicated that arterial stenosis occur in up to 29% of thrombosis cases[17]. SIAPR can be falsely low or normal if the stenosis is proximal to venous needle or if access has accessory veins or collaterals[9]. Recently, Spergel et al[14] concluded in a preliminary report that all types of pressure measurements should be abandoned in favor of access flow measurements. In an attempt to avoid excessive referrals for invasive diagnostic evaluation and intervention using SIAPR surveillance, and to minimize cost and time, a hybrid model combining SIAPR and Qa surveillance protocols has been recommended[10]. We compared SIAPR with blood flow (Qa) in AV access measured through Doppler ultrasound in 113 maintenance hemodialysis patients at Fatima memorial Hospital. **Figure 3** shows some unpublished data of this interesting study worth mentioning here. It depicts that high SIAPR did not correlate with low blood flow.

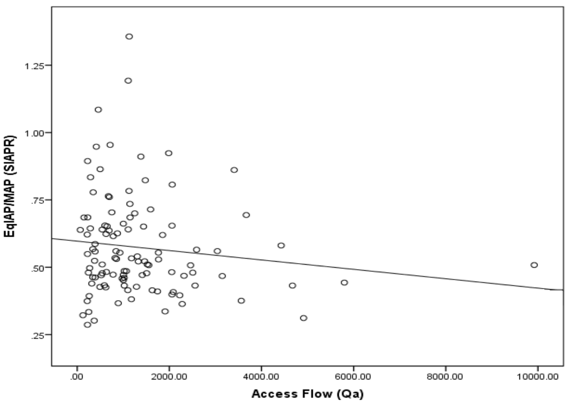

Figure 3: Correlation of static intra access pressure and access blood flow among 113 patients on maintenance hemodialysis, unpublished data.

Conclusion: Intra-access pressure (P_{IA}) is a simple tool which can be used in hemodialysis units for vascular access surveillance and monitoring, although it has a low diagnostic power in detection of vascular access stenosis as compared to other surveillance methods like access blood flow measurements and physical examination but can be used as a complementary method.

References:

1. Besarab A, Asif A, Roy-Chaudhury P, Spergel LM, Ravani P. The native arteriovenous fistula in 2007. Surveillance and monitoring. J Nephrol 2007;20:656-67.
2. Rooijens PPGM, Tordoir JHM, Stijnen T, Burgmans JPJ, Smet de AAEA, Yo TI. Radiocephalic wrist arteriovenous fistula for hemodialysis: meta-analysis indicates a high primary failure rate. Eur J Vasc Endovasc Surg 2004; 28: 571–680
3. Choi Yj, Lee Yk, Park Hc, Kim EY, Cho A, Han C et al. Prediction of vascular access stenosis: Blood temperature monitoring with the Twister versus SIAP ratio.PLoS One. 2018;13(10):e0204630.
4. Vascular Access 2006 Work Group. Clinical practice guidelines for vascular access. Am J Kidney Dis 2006;48 Suppl 1:S176-247.
5. National Kidney Foundation:K/DOQI Clinical practice guidelines for vascular access. Am J Kidney Dis 2001 37(Suppl 1):S137–S181.
6. Schwab SI, Raymond FR, Saeed M, Newman GE, Dennis PA, Bollinger RR: Prevention of hemodialysis fistula thrombosis: Early detection of venous stenosis. Kidney mt 198936:707-7 1 1.
7. Besarab A. Dorrell S, Moritz M, Michael H, Sullivan K: Determinants of measured dialysis venous pressure and its relationship to true intra-access venous pressure. ASAIO Trans 1991;37: M270- M27l.
8. Besarab A, Al-Saghir F, Alnabhan N, Lubkowski T, Frinak S: Simplified measurement of intra-access pressure. ASAJO 1996 J 42: M682-M687.
9. Abreo K, Amin BA, Abreo AP, Physical examination of the hemodialysis arteriovenous fistula to detect early dysfunction, The Journal of Vascular Access, 2019;20(1);7-11.
10. Besarab A. Preventing vascular access dysfunction. Which policy to follow.Blood Purif 2002;20:26-35
11. Besarab A, Sullivan KL, Ross RP, Moritz MJ. Utility of intra-access pressure monitoring in detecting and correcting venous outlet stenoses prior to thrombosis.Kidney Int 1995;47(5): 1364-1373.
12. Besarab A, Frinak S, Sherman Ra, Goldman J, Dumler F, Devita MV et al: Simplified measurement of intra-access pressure. J AmSoc Nephrol 1998;9:284–289.
13. Smits JH, Linden J van der, Hagen EC, Modderkolk-Cammeraat EC, Feith GW, Koomans HA et al. Graft surveillance: venous pressure, access flow, or the combination? Kidney Int 2001;59: 1551–1558
14. Spergel LM, Holland JE, Fadem SZ, McAllister CJ, Peacock EJ. Static intra-pressure ratio does not correlate with access blood flow. Kidney Int 2004; 66: 1512–1516
15. Kleinekofort W, Kraemer M, Rode C, Wizemann V: Extracorporeal pressure monitoring and the detection of vascular access stenosis. Int J Artif Organs 2002;25:45–50.
16. Valji K, Bookstein JJ, Roberts AC, Oglevie SB, Pittman C, O'Neill MP. Pulse-spray pharmaco mechanical thrombolysis of thrombosed hemodialysis access grafts: Long-term experience and comparison of original and current techniques. Am J Roentgenol 1995;164:1495–1500.