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Mini Reveiw

Prepump Arterial Pressure Monitoring during Hemodialysis: A Mini Review

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ABSTRACT

The monitoring of Prepump Arterial pressure (Pa) during hemodialysis session can not only strengthen the safety of treatment, but also indicate the Vascular Access (VA) function and the rationality of the pump control blood pump flow (Qb) setting on the machine. Despite this, the monitoring of Pa is always ignored and the measurement or safe range of Pa has not yet emerged as a clinical standard in worldwide practice. The absolute value of the ratio of Pa to Qb (|Pa/Qb|) was proved to be an independent risk factor and a predicting factor for arteriovenous fistula function. However, |Pa/Qb| is related to various influencing factors, and attention should be paid to exclude confounding factors and avoid risk factors that contributed to not only change of |Pa/Qb| but also complications of VA.

Keywords: Vascular access; Hemodialysis; Arterial pressure; Arteriovenous fistula

INTRODUCTION

Vascular Access (VA) of hemodialysis patients, also called the lifeline of hemodialysis patients, is the key to completing hemodialysis treatment. Prepump Arterial pressure (Pa) is a negative pressure generated by the blood pump supplying blood into the arterial segment of the hemodialysis circuit and indicates the ease or difficulty with which the blood pump can draw blood from VA (inflow) during hemodialysis [1]. The monitoring point of Pa is located before the blood pump, mainly measured by pressure sensor or negative pressure sac. The values detected by the pressure sensor can be displayed on the hemodialysis machine in real time, while the negative pressure sac monitoring mainly depends on the nurse's judgment of its filling situation. The values detected by the pressure sensor installed on the sensory module and can be displayed on the hemodialysis machine in real time, while the negative pressure sac monitoring mainly depends on the nurse's judgment of its filling situation. The harder the negative pressure sac the greater is the pressure.

The monitoring of Pa can not only strengthen the safety of treatment, such as preventing hemolysis and needle removal, but also indicate the VA function and the rationality of the blood pump speed setting. Pa monitoring can reduce the damage to VA caused by extreme negative pressure and too close position of puncture needle to the vascular wall resulted by negative pressure [2].

LIMITATION IN CURRENT PRACTICE AND PREVIOUS RESEARCH

Despite this, the monitoring of Pa is always ignored. Pa is not monitored regularly in nearly half of the hemodialysis centers [3]. And the measurement or safe range of Pa has not yet emerged as a clinical standard in worldwide practice [1,4].

The KDOQI clinical practice guidelines recommend that the Pa should not fall below −250 mmHg, since excessively negative Pa can lead to a decrease in delivered blood flow of VA and subsequent inadequate hemodialysis [5]. Shibata noted that the optimal Pa value for preventing hemolysis should not be less than -150 mmHg [1]. However, even if Pa is within the recommended range, clinical problems of repeated aspiration and vascular collapse occur. Therefore, the scope of reference to the above Pa is not sufficient for a reference to the protection of VA. In fact, the reason for the large differences in Pa ranges in different studies may be for different blood pump speed (Qb) settings on the hemodialysis machine, which are often overlooked by previous studies. Pa mainly relies mainly on Qb

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[6]. The greater the Qb, the absolute value of the Pa also increases. When the Qb is unchanged, the absolute Pa value indicates that the VA blood flow may be insufficient. Therefore, it's not appropriate to determine the adequacy of the blood flow of VA simply by the size of the Pa without considering the Qb.

THE VALUE OF MONITORING BY COMBINATION OF QB AND PA

According to the Poiseuille's formula, the pressure is divided by flow equal to flow resistance ($R=\Delta p/Q$). Therefore, the absolute value of the ratio of Pa to Qb (|Pa/Qb|) reflects the blood flow resistance. The increased resistance of blood flow can not only result in hemolysis, circulation pipeline coagulation and insufficient dialysis problems [1], but also lead to the collapse of blood vessels, causing vascular intima damage, stenosis and thrombosis of VA and affecting the service life of the VA [5]. Therefore, it is more meaningful to study |Pa/Qb| than Pa. Besarad et al. proposed that |Pa/Qb| could be used for judging or predicting the dysfunction of catheter. Results in their study showed that most large-gauge catheters with |Pa/Qb| of more than 0.5, suggesting impending access dysfunction, which may warrant intervention [6]. However, there were few system studies had focused on the indicating and predictive role of |Pa/Qb| in other type of VA dysfunction.

A study taking ArterioVenous Fistula (AVF), the main type of VA for hemodialysis patients as a entry point, analyzed 1-year data of 490 patients. Results showed that |Pa/Qb| was an independent risk factor of AVF dysfunction [7]. Then the pattern of the association between |Pa/Qb| and AVF dysfunction was evaluated by using a Cox proportional hazards regression model with restricted cubic splines [8]. Results demonstrated that there was a U-shaped association between |Pa/Qb| and the risk of AVF dysfunction (pnon-linearity<0.001). Both |Pa/Qb|<0.30 and >0.52 were potentially risk intervals for AVF dysfunction. The sensitivity and specificity values were 54.1% and 78.2%, respectively. The positive and negative predictive values were 34.1% and 89.0%. We pointed out that, when |Pa/Qb| is less than 0.30 or greater than 0.52, the patient's AVF function or Qb setting should be reevaluated to prevent subsequent failure. Therefore, |Pa/Qb| is an important reference value for clinical nurses when screening for AVF dysfunction and setting a proper Qb to avoid damage to the VA due to an excessive Pa.

DISCUSSION

Notably, applicability needs to be considered in applying the above conclusions, since the above studies had controlled the influence of the hemodialysis machine and the puncture needle and other confounding factors on |Pa/Qb|. |Pa/Qb| is associated with many other factors in addition to blood flow in the VA.

First, in terms of measurement, the size of |Pa/Qb| may be related to the measurement accuracy, and it is recommended that the engineer calibrate the hemodialysis machine regularly. Second, the factors influencing patency of hemodialysis circuit leading to change of |Pa/Qb| should be addressed, such as needle clogging or sticking to the wall of vascular, and discounted or clogged tube before the blood pump during hemodialysis session. Third, |Pa/Qb| represents blood flow resistance and is related to blood components, such as hematocrit, hemoglobin concentration, etc, which also contributed to the high risk of thrombosis of VA [9]. Last but not not least, hypotension or a high Qb setting which was higher than the actual blood flow of vascular may contributed to the increase of |Pa/Qb|, then lead to the complications of VA. Hypotension during hemodialysis session can lead to increase in |Pa/Qb|, as the blood flow of the arteriovenous fistula is driven by the pressure drop, and the pressure drop is determined by the mean arterial pressure minus the central venous pressure [10]. And studies have shown that frequent episodes of hypotension during hemodialysis are associated with an increased incidence of VA thrombosis [11]. Also, too high Qb setting in pursuit of hemodialysis adequacy causes an increase in |Pa/Qb|. Large values of | Pa/Qb | may indicate that the vascular access may not meet the requirements of the Qb prescription. Therefore, forcibly setting Qb too high will cause the blood vessel to collapse, which will cause intimal hyperplasia of the vascu1ar access over time. Recent research has shown that a higher Qb would increase the shear force near the needle and increase the risk of thrombosis [12]. It is recommended that nurses should lower the Qb (but not lower than the minimum prescription requirements) to make the |Pa/Qb| in the safe range to protect VA after excluding other influencing factors.

Therefore, the application of | Pa/Qb| can not only help nurses judge the VA function, but also judge the patency of extracorporeal circuit before the blood pump, whether the needle tip position is appropriate, hypotension and whether the Qb setting is too high by analyzing the influencing factors of | Pa/Qb|. Then, attention should be paid to exclude relevant confounding factors and to avoid risk factors that cause | Pa/Qb| abnormalities and can cause complications of VA when apply |Pa/Qb| into VA function monitoring.

CONCLUSION

Monitoring by combination of Qb and Pa can improve maintaining of VA. Medical staffs should strengthen the clinical application of |Pa/Qb| during hemodialysis sessions. The application of | Pa/Qb| can not only help nurses judge the VA function, but also identify many adverse events during hemodialysis session. And attention should be paid to exclude confounding factors and avoid risk factors that not only contributed to change of |Pa/Qb| but also to complications of VA when apply |Pa/Qb| into VA function monitoring. In the future, more prospective studies are needed to explore the monitoring value of |Pa/Qb| in other type of VA and in wider populations.

REFERENCES

1. Shibata E, Nagai K, Takeuchi R, Noda Y, Makino T, Chikata Y, et al. Re-evaluation of pre-pump arterial pressure to avoid inadequate dialysis and hemolysis: importance of prepump arterial pressure monitoring in hemodialysis patients. Artificial Organs. 2015; 39(7): 627-634.

2. Fulker D, Simmons A, Barber T. Computational model of the arterial and venous needle during hemodialysis. J Biomech Eng. 2017; 139(1): 011005.
3. Xiang Y, Zhen D. Do you monitor the prepump arterial pressure. 2020.
4. Polaschegg HD. Neglected safety aspects in hemodialysis machines and their related problems. J Hemodial Horiz. 2006; 65-68.
5. Vascular Access Work Group. Clinical practice guidelines for vascular access. Am J Kidney Dis. 2006; 48 : S176-S247.
6. Besarab A, Pandey R. Catheter management in hemodialysis patients: Delivering adequate flow. J Clin J Am Soc Nephro. 2011; 6(1): 227-234.
7. Sun CY, Mo YW, Lan LJ, Han XW, Song L, Zhang GR, et al. It is time to implement prepump arterial pressure monitoring during hemodialysis: A retrospective multicenter study. J Vasc Access. 2020; 21(6): 938-944.
8. Sun CY, Zhou LF, Song L, Lan LJ, Han XW, Zhang GR, et al. How to reduce the risk of arteriovenous fistula dysfunction by observing prepump arterial pressure during hemodialysis: A multicenter retrospective study. J Blood Purif. 2021; 2: 1-8.
9. Twardowski ZJ, Haynie JD, Moore HL. Blood flow, negative pressure, and hemolysis during hemodialysis. J Hemodial Int.1999; 3(1): 45-50.
10. Asif A, Agarwal AK, Yevzlin AS. Chinese translation version. Beijing: Science Publishing House. 2015.
11. Chang TI, Paik J, Greene T, Desai M, Bech F, Cheung AK, et al. Intradialytic hypotension and vascular access thrombosis. J Am Soc Nephrol. 2011; 22(8): 1526-1533.
12. Quicken S, Huberts W, Tordoir J, van Loon M, Delhaas T, Mees B. Computational modelling based recommendation on optimal dialysis needle positioning and dialysis flow in patients with arteriovenous grafts. Eur J Vasc Endovasc. 2020; 59(2): 288-294.