A New Type of Double-Lumen Catheter to Replace Current One in RCA

Yingfeng Xue[1,2]*, Zhenguo Yu[1]

[1]Xili Hospital, Shenzhen, China
[2]Department of Nephrology, First Affiliated Hospital of Dalian Medical University, Dalian, China
Email: *2460212916@qq.com

Abstract

Objective: To replace the peripheral venous puncture for blood sampling with taking blood samples extracorporally from arterial line before predilution during RCA-CRRT performed. **Methods**: A new type of double-lumen femoral catheter was used instead of the current tubes. The new type of double-lumen tube had a greater distance from the inner venous ports to the inner arterial ports than current tubes. The minimum distance from the venous port to the arterial port was greatly lengthened. Replacement solution contained citrate, zero Ca^{2+}, zero bicarbonate, low Na^+. Blood samples were synchronously collected from the arterial line before the infusion of citrate replacement fluid and from the peripheral vein. The iCa concentration data of two groups were analyzed to observe the difference between iCa concentration levels in the arterial line and in peripheral vein; the anticoagulant effect of RCA and possible complications were observed, such as bleeding, clottings and hypocalcaemia. **Results**: 28 times of RCA-CRRT were performed on17 AKI and CRF patients with active bleeding or at the high risk of bleeding; 336 blood samples were collected. Statistics showed that the difference of iCa concentration between arterial line group and the peripheral vein group was not significant (P = 0.9), there is a high degree of similarity between the iCa concentration of arterial line blood and the peripheral venous blood. None of the patients developed citrate toxicity or metabolic alkalosis. None induced bleeding, or bleeding aggravated. No obvious clotting occurred. Systemic calcium concentration was achieved in the ideal range. **Conclusion**: In clinical practice, the data of iCa concentration from arterial line can be used to replace that from peripheral vein when the new type of double-lumen femoral catheter is placed in femoral vein. RCA-CRRT therapy is safe and effective.

Keywords

RCA-CRRT, Ionized Calcium, Arterial Line, Peripheral Vein, New Type of

Double-Lumen Femoral Catheter

1. Introduction

With rapid popularization of blood purification, the morbidity of bleeding or high risk of bleeding is gradually increasing in patients who required continuous renal replacement therapy (CRRT) in ICU. Regional citrate anticoagulation (RCA) for CRRT is associated with a longer filter life span and fewer bleeding events. However, the complexity of the regimen is the major hurdle preventing widespread application [1] [2] for example, frequent peripheral vein puncture for blood sampling. In order to simplify the cumbersome operating procedures of blood sampling, a new type of double lumen catheter was located in the patient's femoral vein, in which the minimum distance from the inner venous port to the inner arterial port was lengthened to 6 cm long, then, extracorporeal circulation connected via arterial and return lines. Blood samples were taken both from the arterial line before predilution and the peripheral vein synchronously, and in turn, were tested immediately. The difference of iCa levels was assessed between arterial line and peripheral vein, which if, was caused by recirculation. If there is a high degree of consistency to two groups, the iCa data tested from arterial line blood sample can be used to replace that from peripheral vein, finally the cumbersome sampling by venous puncture from peripheral vein can be left out and be substituted by taking from arterial line. As a result, a new simplified sampling method will be provided for a completely automatic RCA machine with the function of iCa automatic monitoring online. The currently used double lumen femoral catheters seem not competent to this machine due to blood recirculation [3].

2. Methods

Seventeen critically ill patients with bleeding or at the high risk of bleeding were evaluated in ICU during the period of 2014.10-2016.7. The study was approved by the Ethics Committee of Xili Hospital. 28 times of RCA-CRRT were performed after obtaining informed consent. The median age of patients was 49.1 years (range, 13 to 80); 9 men, 8 women; Of 17 patients with bleeding or at the high risk of bleeding, 2 AKI caused by acute heart failure, 1 Acute exacerbation on CRF, 2 Cerebral hemorrhage, 1 ARDS, 1 Hellp syndrome, 1 Thermoplegia, 1 Sepsis, 1 acute nephritis , 3 occurred after bone marrow transplantation, 1 after renal transplantation, 3 CRF respectively complicated with hyperkalemia, fundus hemorrhage and gastrointestinal hemorrhage. CVVH was performed using the Fresenius Medical Care with AV-400/600 filter. The circuit was run for 6 - 20 hr, 11 hr on average; a new type of double lumen YXD-12F.24cm catheter (YXD. Co., Ltd., Shenzhen, Guangdong, China) was placed into femoral vein for vascular access by the physicians. The minimum distance from the inner venous port to the inner arterial port was lengthened to 6 cm long；the length inside the vein of this new type of double lumen catheter stands for 24 cm long: See Figure 1, Photo 1 and Photo 2.
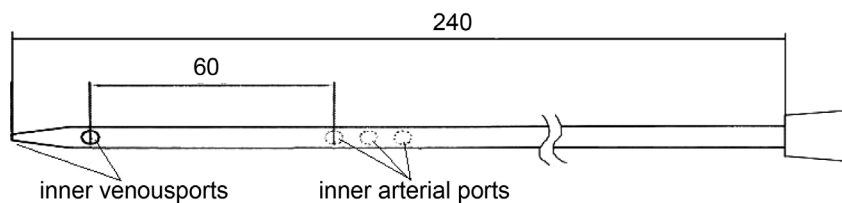
Figure 1. Distance from the inner venous port to the inner arterial port.

Photo 1. The object of distance from the inner venous port to the inner arterial port.

Photo 2. The object of distance from the inner venous port to the inner arterial port.

The blood flow rate was maintained at 150 mL/min, and replacement solution contained 13.3 mmol/L citrate, zero Ca^{2+}, zero bicarbonate [4] running at three different rates of 2000 - 2500 - 3000 ml/h was the only predilution replacement fluid. The rate of predilution replacement fluid varied with patients' coagulation test result before the treatment. 336 blood samples were synchronously collected from the arterial line in the circuit before the infusion of citrate replacement fluid, from the peripheral vein (iCa waved preferably from 0.99 - 1.25 mmol/L) and from the return line. The one from arterial line was put into group 1; that from peripheral vein group 2. During the treatment, systemic iCa, serum electrolytes, and arterial blood gases were measured at the end of first hr, then every 3 h for 20 h. Additional blood tests were performed as needed based on clinical indications. 10% calcium gluconate was infused in the way of echelon [5] into return line at the point just before the entrance into the body via a 3-way stopcock and was titrated to achieve a systemic iCa level ranged at 0.99 - 1.25 mmol/L. Potassium was added to the pre-replacement fluid for those patients who required supplementation. Rates of hemofilter clotting, significant bleeding events, metabolic alkalosis (defined as pH > 7.50 [1]) and evidence of citrate toxicity were observed (Table 2).

3. Statistical Analysis

Data are reported as the median and standard deviation. The analysis was performed by the Statistical Center of Shenzhen University Town. SPSS version 18.0.

4. Results

The data of our study are shown in Table 1, Table 2 and Figures 2-6. The relation

Table 1. Relationship between arterial line iCa and the peripheral vein.

Paired T test	Median (mmol/L)	SD (mmol/L)	Sampling times	T Value	P value
Group1	1.10858	0.090904	112	0.000	1.000
Group2	1.10858	0.090337	112	0.000	1.000

Table 2. Clinical characteristics and laboratory parameters.

	RR	BP	HR	Scr	APTT	PH	Lip Numbness	Clotting
1 h (n − 28)	21 ± 5	134 ± 17/81 ± 14	91 ± 25	602 ± 467	39 ± 10	7.33 ± 0.08	0	0
2 h (n − 28)	19 ± 2	130 ± 21/78 ± 14	89 ± 21		40 ± 9		0	1
8 h (n − 26)	16 ± 2	126 ± 25/78 ± 13	89 ± 20		37 ± 8		0	0
11 h (n − 22)		130 ± 14/79 ± 10		339.9 ± 268.5		7.43 ± 0.025	0	0
14 h (n − 6)		123 ± 4.6/76 ± 3.7			44 ± 7.9	7.46 ± 0.016	0	0
17 h (n − 1)	17	122/74	80		27.3		0	0
20 h (n − 1)	18	120/75	82		37	7.47	0	0

n: Number of patient enrolled; RR: Respiratory rate; BP: Blood pressure; HR: Heart rate; SCr: Serum creatinine; Lip numbness: a symptom of citrate toxicity.
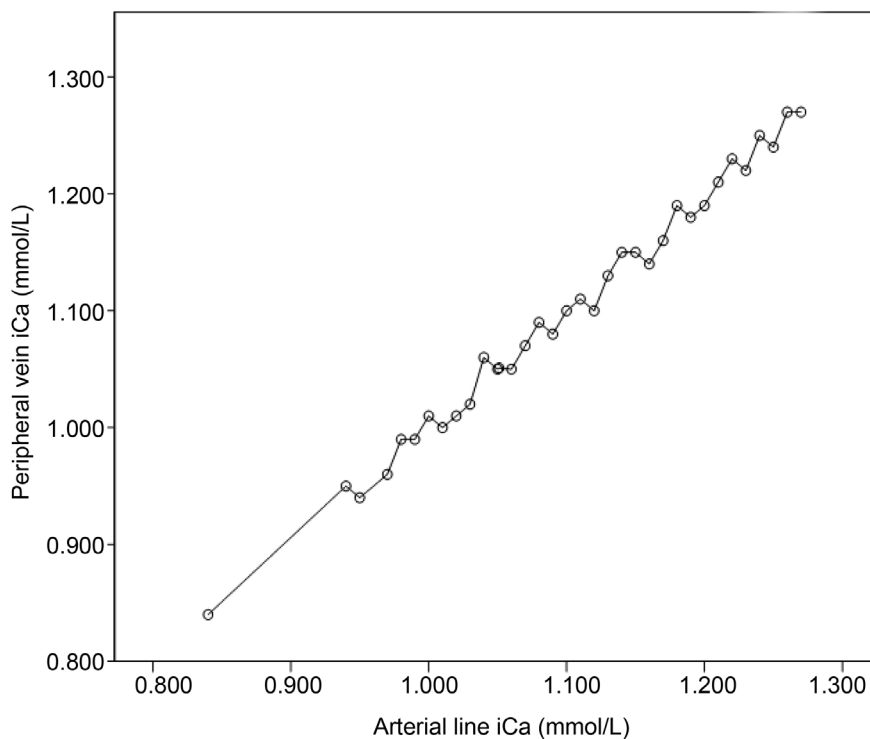
Figure 2. One element linear regression scatter plot for iCa of arterial line and the peripheral vein.

between group 1. (1.10858 ± 0.0909 mmol/L) and group 2. (1.10858 ± 0.0903 mmol/L) were analyzed by means of paired t-test, two element correlation and one-element linear regression. T-test result shows: P > 0.9, there is not significant difference between

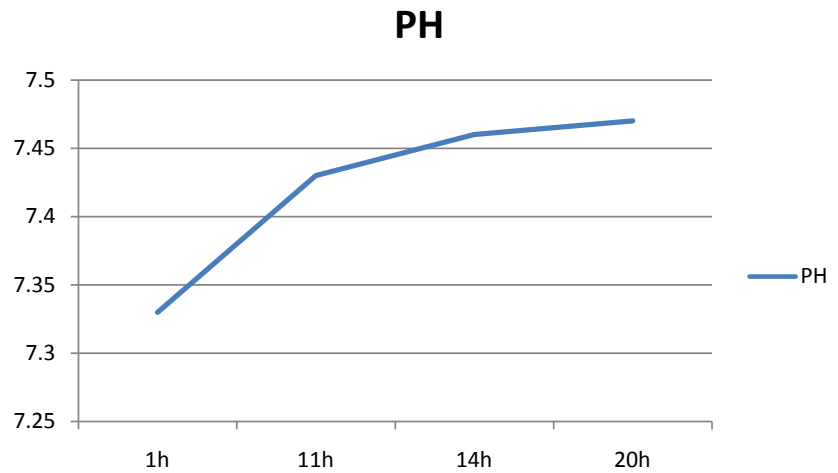**PH**
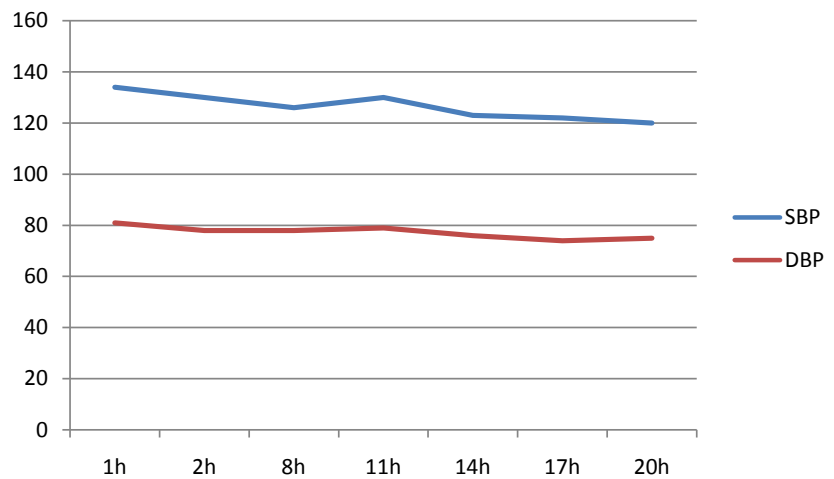

Figure 3. pH variation during treatment.

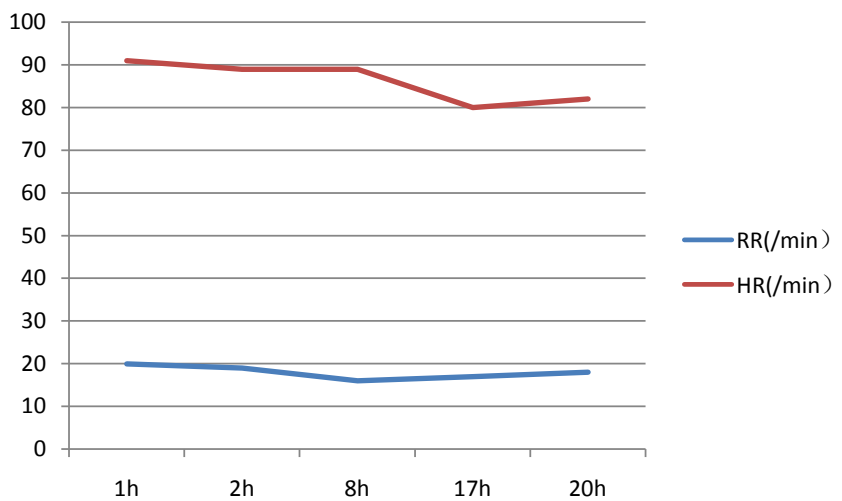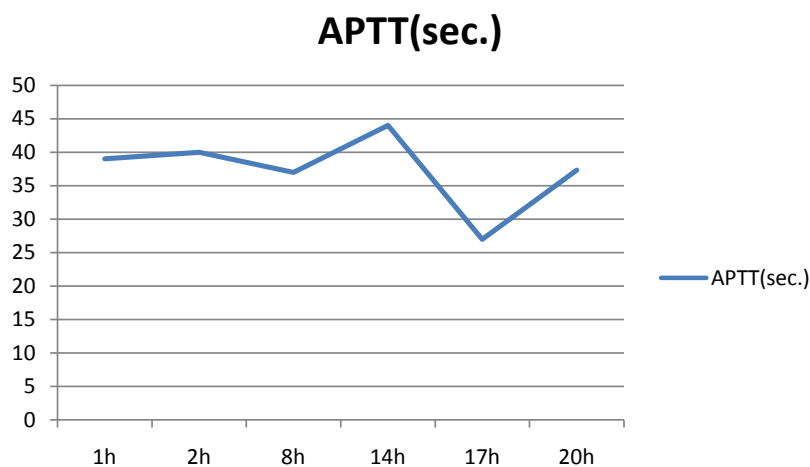**Figure 4.** Blood pressure variation during treatment. SBP: systolic blood pressure; DBP: diastolic blood pressure.

Figure 5. Respiratory rate and heart rate variation during treatment.

APTT(sec.)

Figure 6. APTT variation during treatment.

the values of iCa concentration of two groups; correlation: R = 0.992; linear regression equation is fitted: arterial line iCa = 0.001 + 0.999* Peripheral iCa, R^2 = 0.985, P < 0.001. The results analyzed above suggested that the iCa value from arterial line has a high degree of consistency to that from the peripheral vein; The iCa value of arterial line can be used to replace the one punctured from peripheral vein when this new type of double lumen femoral catheter is applied during RCA-CRRT. See Table 1 and Figure 2.

The values of PH, blood pressure, respiratory rate, heart rate and APTT waved as shown in Figures 3-6. PH value improved and elevated (from 7.33 ± 0.08 to 7.46 ± 0.016, even to 7.47, n = 1) gradually during the treatment period (Figure 3). But no other clinical metabolic alkalosis manifestions. No citrate toxicity such as lip numbness was observed (Table 2). Blood pressure gradurally reduced from 134 ± 17/81 ± 14 mmHg to 123 ± 4.6/76 ± 3.7 mmHg during treatment without clinical significance (Figure 4). Respiratory rate (range from 21 ± 5/min to 16 ± 2/min)and heart rate ((range from 91 ± 25/min to 89 ± 20/min) fluctuated within a narrow range (Figure 5). APTT varied in normal range (Figure 6).

Other characteristics were shown in Table 2 and Figures 3-6.

In one patient a filter was changed because of clotting caused by malposition of catheter tip and the failure to deal with the machine alarm; other circuits were run for 6 - 20 hr, 11 hr on average and stopped electively. Systemic iCa level was maintained within the target level (0.95 - 1.27 mmol/L); iCa level from return line maintained at 0.17 - 0.49 mmol/L. Blood flow was maintained at 150 mL/min for all patients. No additional sodium bicarbonate was given to any of the patients. The pH and base excess improved gradually during the treatment period. No citrate toxicity and metabolic acidosis occurred.

5. Discussion

The cumbersome blood sampling by venous puncture from peripheral vein is the main

part of the complexity of RCA regimen. In order to solve this problem, we tried to take the blood samples extracorporeally from arterial line before predilution instead of venous puncture for blood sampling from peripheral vein.

The currently used double lumen femoral catheters seem not competent to offer such a sample due to blood recirculation [3]. The tested value of iCa from arterial line is not equal to that from peripheral vein because of recirculation. To attempt greatly reduce the this regional recirculation, we used a new type of double lumen catheter in the patient's femoral vein, in which the minimum distance from the inner venous port to the inner arterial port was lengthened to 6 cm long, and the length inside the vein of this new type of double lumen catheter stands for 24 cm long. The outcome of our study shows that there is a high degree of consistency to group 1 and group 2, the iCa data tested from arterial line blood sample can be used to replace that from peripheral vein. The utilization of this new type of femoral double lumen catheter made it possible to reduce the regional blood recirculation close to zero, furthermore, realized detection of systemic iCa level without cumbersome venous puncture when RCA-CRRT is performed. In the future, this new simplified sampling method will be used for a completely automatic RCA machine with the function of iCa automatic monitoring online.

Our study enrolled 17 cases, it is not a large sample statistically. With the sample extending , more concrete data will be reached. The shortage of this catheter is that the femoral vein is the only location to be placed, it can not be used in jugular vein. Finally, if there is a new totally coagulating-proof hemofilter and extracorporeal circuit set developed successfully, this new catheter will work only as an ordinary double-lumen catheter with the superiority described above lost.

From a clinical point of view, the variations of other clinical parameters such as Bp, HR, RR, APTT were within normal range. SCr reduced reasonably.

6. Conclusion

RCA-CRRT is safe, effective, easy to handle. This type of double-lumen catheter will replace the current one in RCA. It will contribute to completely automatic RCA machine with the function of iCa automatic monitoring online in the near future.

References

[1] Shum, H.-P., Chan, K.-C., Yan, W.-W., *et al.* (2012) Regional Citrate Anticoagulation in Predilution Continuous Venovenous Hemofiltration Using Prismocitrate 10/2 Solution. *Therapeutic Apheresis and Dialysis*, **169**, 81-86.
http://www.ncbi.nlm.nih.gov/pubmed/22248200
http://dx.doi.org/10.1111/j.1744-9987.2011.01001.x

[2] Evenepoel, P., Maes, B., anwalleghem, J.V., *et al.* (2002) Regional Citrate Anticoagulation for Hemodialysis Using a Conventional Calcium-Containing Dialysate. *American Journal of Kidney Diseases*, **39**, 315-323. http://www.ncbi.nlm.nih.gov/pubmed/11840372

[3] Little, M.A., Conlon, P.J. and Walshe, J.J. (2000) Access Recirculation in Temporary Hemodialysis Catheters as Measured by the Saline Dilution Technique. *American Journal of Kidney Diseases*, **35**, 477-481.

http://www.ncbi.nlm.nih.gov/pubmed/?term=Access+recirculation+in+temporary+hemodialysis+catheters+as+measured+by+the+saline+dilution+technique

[4] Palsson, R. and Niles, J.L. (1999) Regional Citrate Anticoagulation in Continuous Venovenous Hemofiltration in Critically Ill Patients with a High Risk of Bleeding. *Kidney International*, **55**, 1991-1997. http://www.ncbi.nlm.nih.gov/pubmed/10231464
http://dx.doi.org/10.1046/j.1523-1755.1999.00444.x

[5] Zheng, Y. and Ding, F. (2015) Application of RCA in CRRT. *Chinese Journal of Blood Purification*, **1**, 47-50.