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The use of a transit time flow meter in arteriovenous fistula and the evaluation of its effect on early period fistula patency

El uso de un medidor del tiempo de tránsito del flujo en la fístula arteriovenosa y la evaluación de su efecto en la permeabilidad temprana de la fístula

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RESUMEN

Objetivo: Las operaciones de fístula arteriovenosa (FAV) son el método más común para facilitar la hemodiálisis en pacientes con insuficiencia renal crónica. La longevidad de la FAV es vital en pacientes sometidos a hemodiálisis. Investigamos el efecto del uso del medidor del tiempo de tránsito de flujo de (TTFM) en la permeabilidad de la FAV. **Métodos**: Se incluyeron en el estudio 108 pacientes (42 en el grupo de estudio, 66 en el grupo control) que se sometieron a confección de FAV por primera vez en los últimos cinco años. En las mediciones realizadas con TTFM, si el índice de pulsatilidad (IP) era > 5 y el valor de flujo medio < 30 ml/min, las FAV se consideraban insuficientes. **Resultados**: La edad, el sexo, los valores de lipoproteínas de baja densidad (LDL), la extremidad no dominante y la enfermedad arterial periférica acompañante en los grupos de estudio fueron similares, y el tabaquismo en el grupo de estudio y la hipertensión en el grupo control fueron los factores de riesgo más comunes. El PI y los caudales medios con TFTM en el grupo de estudio estaban dentro del rango normal. No se encontraron diferencias estadísticamente significativas en las tasas de permeabilidad de la FAV cuando comparamos los diferentes períodos entre los grupos. Sin embargo, al evaluar la permeabilidad de la FAV de los grupos en todo el período, se determinó que la permeabilidad en los pacientes del grupo de estudio era mejor que la del control, siendo este hallazgo estadísticamente significativo. **Conclusión**: El uso intraoperatorio de TTFM ayuda a detectar la disfunción de la FAV. Este método proporciona un tiempo de permeabilidad vascular más prolongado. Aumenta la comodidad del paciente al prolongar la función y la vida de la FAV.

PALABRAS CLAVE: Insuficiencia Renal; Flujómetro; Permeabilidad de Fístula

ABSTRACT

Objective: Arteriovenous fistula (AVF) operations are the most common method to facilitate hemodialysis in patients with chronic renal failure. The longevity of AVF is vital in patients undergoing hemodialysis. We investigated the effect of Transit Time Flow Meter (TTFM) use on AVF patency. **Methods**: 108 patients (42 in the study group, 66 in the control group) who underwent AVF formation for the first time in the last five years were included in the

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study. In the measurements made with TTFM, if the pulsatility index (PI) was >5 and the mean flow value was <30 mL/min, AVFs were considered insufficient. **Results**: Age, gender, low-density lipoprotein values (LDL), non-dominant extremity, and accompanying peripheral artery disease in the study group of patients were similar, and smoking in the study group and hypertension in the control group were the most common risk factors. PI and mean flow rates with TFTM in the study group were within the normal range. No statistically significant difference was found in the AVF patency rates when we compared the different periods between groups. However, when evaluating the AVF patency of the groups in the whole period, it was determined that the patency of the patients in the study group was better than the control, and this finding was statistically significant. **Conclusion**: Intraoperative use of TTFM helps detect AVF dysfunction. This method provides a longer vascular patency time. Increases patient comfort by prolonging the function and life of the AVF.

KEYWORDS: Renal Failure; Flowmeter; Fistula Patency

INTRODUCTION

Arteriovenous fistula (AVF) operations are the most frequently used method to facilitate hemodialysis in patients with chronic renal failure and thus improving the patient's quality of life [(1)]. In hemodialysis, reaching a large enough vessel is necessary to ensure adequate blood flow and reproducible extracorporeal flow. Meeting this need is best with primary AVFs. Two conditions are necessary for an arteriovenous fistula (AVF) to be usable as dialysis access. It must have adequate blood flow, and it must have a size that will allow easy cannulation. Using Brescia-Cimino radio cephalic AVFs for hemodialysis has become a standard method [(2)]. The blood flow required in hemodialysis depends on the flow in the venous part of the arteriovenous anastomosis [(3)].

The success of this procedure depends on the anastomosis technique and the structure of the vessel selected for surgical intervention.

Vascular access loss is the biggest challenge in chronic hemodialysis. The most common cause of this loss is thrombosis. Care should be taken during early surgical evaluation to ensure the long-term patency of AVFs. Avoiding previous unnecessary and frequent venous punctures of the veins of the upper extremities or percutaneous catheter interventions that may cause subclavian vein stenosis or occlusion and mainly using jugular or femoral vein access [(4)] is vital. Finally, the use of autogenous vessels and opening of distal AVFs in the first place is preferable.

The insufficient blood flow in the anastomosis after AVF may be due to faulty surgical techniques. Detection of insufficient blood flow caused by a technically correctable error during the operation will reduce the risk of flow failure, fistula failure, and reoperation. Surgeons should evaluate anastomoses made in AVF operations qualitatively. However, a practical, easy-to-qualify method applied by surgeons for this matter is lacking. The longevity of the AVF, which occurs in patients who need hemodialysis due to kidney failure, is critical. The transit time flowmeter is an auxiliary device to measure blood flow and anastomoses' functioning in coronary bypass patients.

This study divided patients with primary arteriovenous fistula into two groups. The AVF measurement in the study group was made with a transit time flow meter (TTFM) during the operation, and in the control group, it was made by manually taking the trill.

Postoperative AVF patency rates in these groups were investigated and compared retrospectively. Thus, the effect of TTFM used during the operation to measure the patency of the fistula after the operation was investigated.

MATERIALS and METHODS

Patient selection protocol

Between January 2016 and January 2021, one hundred and eight patients who had AVF for the first time in our clinic were investigated. The study group included forty-two patients, including sixty-six in the control group. The AVFs of patients were divided into two groups: proximal (brachial area) and distal (radial area), comparing the findings obtained regionally and in total. The patients were investigated in two groups, and then the findings were compared, obtaining the data from hospital records.

Definitions

Chronic renal failure (CRF) is defined

as a glomerular filtration rate below 30 ml/min per 1.73 m2 body surface area. We considered *Infections* when there were local vascular access infections, vascular access–related sepsis, bacteremia, or a composite of these infections. *Steal syndrome* was defined as one or more clinical manifestations of pain, ischemic neuropathy, ulceration, and gangrene, related to a fistula diverting blood from the distal circulation, resulting in a zone of arterial insufficiency in the tissues distal to the fistula. The thrombosis is definite by the absence of bruit or thrill, using auscultation and palpation, throughout systole and diastole at least 8 cm proximal to the arteriovenous anastomosis. Smoking, DM, and hypertension, which are atherosclerotic risk factors, were accepted as risk factors for fistula occlusion. If the pulsatility index (PI) was >5 and the mean flow value was <30 mL/min, AVFs were considered insufficient.

Patient Follow-up

The AVFs of the patients were checked on the first day, the seventh day, the first month, the second month, and the third month after the operation. In the AVF control group, evaluation by a manual trill was the first, using Color Doppler ultrasonography (CDUS) in the patients who could not get the trill.

Surgical technique

Surgeons from the same medical school performed all operations using the same technique, surgical sets, and materials, preferring the non-dominant arm primarily for the operation. Routine pre-operative Allen tests were performed. Cefazolin sodium was administered as a prophylactic antibiotic to all patients before surgery. The procedure was performed under local anesthesia (lidocaine) in all patients. The artery and vein were dissected, and their branches were ligated, hung, and free, performing arteriotomy and venotomy after intravenous administration of 50 U/kg heparin. In the anastomoses, the distal 5-8 cm of the vein was first dilated using a 2F and 3F Fogarty catheter. During the anastomoses, special care was taken to keep the direction of the venous graft unchanged and ensure no folds. Surrounding tissues were dissected above the distal vein and ligating the lateral branches, if any. All operations used the end-to-side anastomosis technique. Pulse control was performed in all patients during and after the operation and taking care to prevent the development of steal syndrome.

Measurement of intraoperative TTFM

After completing the surgical AVF procedure, patients in the study group initiated the flow measurement. The pulsatility index (PI), one of the parameters in the flowmeter

$$PI = \frac{\text{maximun flow-minimun flow}}{\text{Average flow}}$$

was measured, calculating the mean arterial blood pressure of the patients as 135/80 mmHg. The flow in the AVF was recorded with a flowmeter in 42 patients, using flowmeter probes of 3 mm in ten patients and 2 mm in six patients per their vessel diameters, taking special care to ensure performing the measurements when the probe's vein grip was 100%. The device automatically measured the amount of current passing through the fistula during the measurement as the PI of the fistula in mL/min., evaluating the mean flow amount and the PI together. The flow through the fistula with PI >5 and a mean flow <30 was considered insufficient. In the presence of high PI and low flow, all parameters (flow amount, PI, quality of the vessels, adequacy of anastomosis, surgical technique) were evaluated, and deciding whether to perform an AVF revision. In addition, we searched lateral branches in the venous part of the fistula, the distal continuity of the fistula, and whether there was a vein fold, checking additionally for thrombosis and spasm. When completing the flow measurement process, founding no problem, and controlling bleeding, the layers were duly closed, completing the operation.

Flowmeter Device Used

Sono TT FlowLab, FL-10-11001-A, em-tec GmbH, Lerchenberg20, D-86923 Finning, Germany. 2014. SN78877. REF12365.

Statistical analysis

Statistical analysis was performed using IBM SPSS version 20.0 (IBM Corp., Armonk, NY, USA). Descriptive data were expressed as mean ± standard deviation (SD), median (min-max), or number and frequency. Group comparisons of numerical data and categorical data were made with the Mann-Whitney U test and the chi-square test, respectively. A two-way p-value of less than 0.05 was considered a statistically significant difference.

Scientific Consent

The study obtained scientific permission from the ethics committee of our hospital with registration number E-37732058-514.10 and registration number 2021 / 05-102.

Limitations of the Research

The most important limitation is that it is a single-center study. There is no similar study in the literature.

RESULTS

The AVF was created using standard surgical technique and removed by trill palpation in all patients. After applying the standard surgical procedure to all study group members, flow measurements were made and recorded using intraoperative TTFM. AVF controls of the patients in the control group were performed by manually taking the trill during the operation. All patients were followed for three months to check blood flow and occlusion in the AVF, using primarily manual trill presence and color Doppler ultrasonography (CDUS) to assess fistula patency. The results of the two groups were compared and evaluated using SPSS software for statistical comparisons. Patient demographics, laboratory and risk factors data, and flowmeter measurement values of the study group are shown in **Table 1**.

Table 1: Patient demographics, laboratory, and risk factors data, the study group's flowmeter measurement values and statistical comparison of patients

Characteristics of the Patients	**Study Group**	**Control Group**	**p**
Sex			
Male	26 (61%)	48 (72%)	p>0.05
Female	16 (39%)	18 (28%)	p>0.05
Age (years)			
Average	34.5 ± 6.9	37.7 ± 6.9	p>0.05
Interval	24-45	24-54	p>0.05
LDL (mg/dL)	167.2 ± 49.05	156.14 ± 47.03	p>0.05
Side			
Left	40 (95.2%)	56 (84.8%)	p>0.05
Right	2 (4.8%)	6 (15.2%)	p>0.05
Risk Factors of the Patients			
Hypertension	8 (19%)	16 (24%)	p>0.05
Diabetes mellitus	5 (11%)	10 (15%)	p>0.05
Smoking	10 (23%)	14 (21%)	p>0.05
Flowmeter (after the operation)			
PI	1.4 ± 0.3	-	
Average flow velocity (mL/min)	55.36 ± 8.32	-	

Abbreviations: LDL, low-density lipoprotein; **PI**, pulsatility index

The statistical comparison of the postoperative AVF patency rates of the patients in the determined periods is given in **Table 2**.

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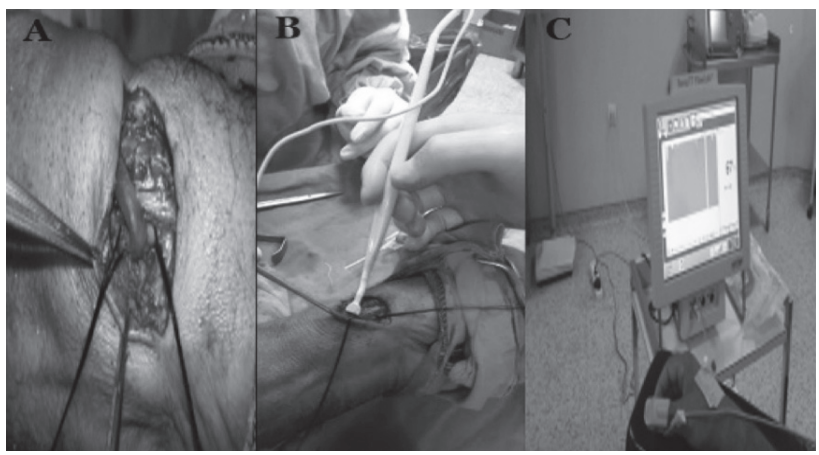
Table 2: Postoperative AVF patency rates and statistical comparison of patients evaluated using CDUS

AVF patency	Study Group	Control Group	p
Occlusion in the AVF			
First day	-	-	
First week	-	-	
First month	1/42 (4%)	3/66 (4.5%)	p>0.05
Second month	-	4/66 (6%)	p>0.05
Third month	1/42 (4%)	6/66 (9%)	p>0.05
Total	2/42 (8%)	13/66 (19.5%)	p<0.05
Fistula Patency	92%	80.5%	p<0.05
Mean Flow Rates using CDUS (mL/min)			
First month	344.22 ± 11.5	299.52 ± 8,43	p>0.05
Second month	594.24± 11.95	481.52 ± 13.50	p>0.05
Third month	658.13± 14.56	613.17 ± 16.60	p>0.05

Abbreviations: AVF, arteriovenous fistula; **CDUS**; color Doppler ultrasonography

The measurement made by TTFM during the patient operation in the study group and the images of the measuring device are shown in **Figure 1**.

Figure 1: The use of a flowmeter in one of our patients belonging to the study group.



References: A) *End-to-side brachiocephalic arteriovenous fistula,* ***B)*** *Measurement made with a 2 mm flowmeter probe,* ***C)*** *A flowmeter*

Study group

Demographics, treatment, and follow-up:

Twenty-six patients were male (n = 26, 61%), and sixteen were female (n = 16, 39%); the mean age was 34.57 ± 6.93 years. The mean low-density lipoprotein (LDL) is 167.21 ± 49.05 mg/dL. Patient concomitant diseases in the study group were hypertension (n:8 19%), smoking

(n:10 23%), and diabetes mellitus (DM) (n:5 11%). Allen's tests of all patients were negative. We performed a radiocephalic AVF in 37 (n: 37, 89%) patients and a brachiocephalic AVF in five (n: 5, 11%) patients. Forty patients' AVFs were on the left side in the non-dominant extremity, and two patients' AVFs were on the right side in the non-dominant extremity. Steal syndrome did not develop in any patients after the operation. In the study group, the mean PI measured by TTFM was 1.4 ± 0.3, and the flow rate was 55.36 ± 8.32 mL/min. The intraoperative anastomosis was revised in three patients because the PI was high, and the flow rate was below 30 mL/min, although removing the trill manually during the operation. After necessary surgical intervention PI and flow rates reached the expected values.

On the postoperative follow-up, we evaluated the patency by hand and, if necessary, with CDUS. At the follow-up, one patient had AVF occlusion (n:1 2%) in the first month and another patient (n:1 2%) in the third month, and the AVF patency was restored by successful surgical intervention.

Control group

Demographics, treatment, and follow-up:

Forty-eight (n = 48, 72%) patients were male, and eighteen (n = 16, 28%) were female. The mean age of the patients was 37.74 ± 6.98 years. Patients' mean low-density lipoprotein (LDL) was 156.14 ± 47.03 mg/dL. Concomitant diseases in the patients in the control group were hypertension (n:16 24%), smoking (n:14 21%), and diabetes mellitus (DM) (n:10 15%). Allen's tests of all patients were negative. Sixty patients received radiocephalic AVF (90%); brachiocephalic AVF was performed in six (n: 6, 10%). In fifty-six patients, AVF was on the left side in a non-dominant extremity, and ten were on the right side in a non-dominant extremity. Stealing syndrome did not develop in any patient after the operation. In all patients, manual trill removal was regarded as the success criterion of the operation. Postoperative trill examination was performed using CDUS. At the follow-up, obstruction was detected in three patients (n:3 4.5%) in the first month, in four patients (n:4 6%) in the second month, and six patients (n:6 9%) in the third month, and AVF patency was achieved with successful surgical intervention.

DISCUSSION

Age, gender, LDL values, non-dominant extremity, and accompanying peripheral artery disease between groups were similar, smoking was the most common risk factor in the study group, and hypertension was the most common risk factor in the control group. PI and mean flow rates of the study group members were within the normal range after measurement with a flow meter. There was no statistically significant difference between findings in the relevant periods related to the patients' AVF patency rates. However, the group comparison regarding the total number of patients with obstruction was statistically significant. In the study group, radiocephalic AVF was performed in 37 (n: 37, 89%) patients and brachiocephalic AVF was performed in five (n: 5, 11%) patients. In the control group, radiocephalic AVF was performed in 60 (n: 60, 90%) patients and brachiocephalic AVF was performed in six (n: 6, 10%) patients. Obstruction was detected in the radio cephalic AVF of two patients in the study group and on the radio cephalic AVF of thirteen patients in the control group, detecting no obstruction in all brachiocephalic AVFs of the two groups during the follow-up period. Radio cephalic AVF surgery performed on patients evaluated in the study group (89%) and control groups (90%) was similar. Occlusion was found in two (n:2 4%) patients with radio cephalic AVF in the study group and thirteen (n:13 19%) patients in the control group. This difference was statistically significant.

The demographics and risk factors of the groups were similar, and there was no statistically significant difference between them. Most of our patients entered dialysis successfully and uneventfully two months after surgery. The time to reach the required flow velocities for patients to enter hemodialysis with AVF fistulas was earlier in the study group and was not statistically significant. Flow velocity values measured by CDUS were higher in the study group than in the control group. When evaluating all group's follow-up periods, the patency rate of AVFs was 95% in the study group and 80% in the control group.

Examining all these results and comparing the groups, when the measurements made during the operations with TTFM were good, they were more valuable than manual trill control for maintaining fistula patency.

AVF operation is widely applied worldwide in patients with renal failure and undergoing hemodialysis and is considered the first choice until achieving kidney transplantation [5]. Despite the frequent application of AVFs, 20-50% failure is observed [6]. The surgery aims to create ideal vascular access to provide adequate blood flow for dialysis without affecting physical activity, protecting the typical vascular structure, and providing hemodialysis by creating a long-term and high-quality AV fistula in this way, with a low complication rate and long-term use [7]. In the non-dominant arm, AVF is the most preferred. There are many other modalities for hemodialysis, where arteriovenous grafts are the least complicated autogenous grafts and have the most extended lifetime [8]. The most critical factor affecting early and late surgical results is the quality of the vessels and anastomoses where the fistula is made. The technique also affects the level of success [9].

Early AVF occlusion's leading causes are anastomosis technical errors, insufficient vein calibration and compression by blood flow, hypotension, and hematoma due to early use. The most common complication in AVF is shunt occlusion due to thrombosis or stenosis [10-11]. *Flowmeter* is a device that has recently become popular among cardiovascular surgeons and has made significant contributions to detecting and correcting technical deficiencies in surgical practice, such as stenosis in the anastomosis and the quality and efficiency of the flow [12]. We used this device to determine whether the fistula function is perfect in patients with AVF. We compared the effect of the fistula on remaining open by eliminating the stenosis that may arise from a surgical application with the patient group operated on without using a device. When insufficiency is detected in the fistula during the operation, correcting the error and ensuring adequate graft flow is usually possible by applying additional minor surgical interventions. Thus, various early and late complications that may develop can be prevented. Sometimes, even in small strictures, if a trill occurs during the operation, it can occlude the fistula. We evaluated the patency of AVFs using TTFM in 42 patients in the study group. In three patients in this group, we detected flow insufficiency in the flow meter measurements during the operation and intervened. Two mm and 3 mm probes were used in this study; the 2 mm probe was used more frequently due to its compatibility with the vessel diameter.

Measurements were made automatically by connecting the probes to the computer system with a screen and software. The current passing per minute was calculated in milliliters, recording the results on the computer. The measurements do not change due to the angle between the vessel and the probe. The flow curve and PI were monitored and recorded simultaneously. In technical problems related to anastomosis, flow values decrease, and PI is found to be high [13]. The mean flow rate expresses the flow in mL/min and does not indicate the quality of the anastomosis. Instead, it indicates the quality of the veins. Low flow rates indicate poor vessel flow rather than the quality of the anastomosis. Therefore, an evaluation should be made by looking at both the current amount and the PI. It is ideal if the current is high, and the PI is low. While making these measurements, the distal pulse should be checked, paying attention to the absence of SS. Many criteria affect the absolute amount of current in an AVF. With the measurements made using the flow meter during the operation, detecting any error and correcting it is possible immediately. An alternative is the use of a CDUS during operation. However, its routine implementation takes a lot of work. Using a flowmeter is easy and takes about 30 seconds to 1 minute. As a result of close follow-up and controls, we found that the patency rates of AVFs in the study group were statistically significant. When comparing the flow rates in the postoperative period, it was seen that the flow rates in the study group were better than the control group.

CONCLUSION

The TTFM is a useful and convenient device for evaluating intraoperative AVF function. This method is very easy to use, does not require much time, can be used easily by everyone, and guides the execution of the operation with sufficient information. Surgical technical errors during flow rate and PI examination can be easily detected and corrected. A few small millimetric anastomoses are time-consuming and very tiring for the patient in an AVF surgery. It would be appropriate to control these small vessel anastomoses, which are vital for the patient, with a method that gives more objective results other than visual inspection or palpation control.

In our study, postoperative patency rates of the patients in the study group measured with TTFM were statistically significant compared to the control group. By using intraoperative TTFM, graft dysfunction will be detected intraoperatively, and after necessary corrections are made, achieving longer vascular patency will result in more successful surgical outcomes, prolonging the function and life of the fistula and increasing patient comfort.

BIBLIOGRAPHY

1) Tezel E, Velidedeoğlu E, Haberal M. Arteriyovenöz Fistüller. In: Haberal M, ed. *Transplantasyon* 1994. Ankara: Haberal Eğitim Vakfı. 1994;199-204.
2) Baltalarlı A, Önem G, Gökşin İ, Yılık L. Brescia-Cimino arteriovenöz fistül deneyimlerimiz. *Journal of Vascular Surgery* 2000;1:28-30.
3) Ateş E, Erkasap S, Karaca İ, et al. Kliniğimizde Hemodiyaliz Amaçlı Açılan A-V Fistüllerin Retrospektif Değerlendirilmesi. *Journal of Vascular Surgery*. 1998;147-150.
4) Gökşin İ, et al. Arteriyovenöz fistül operasyonları: erken ve geç dönemde revizyon gerektiren komplikasyonlar. *Turkish Journal of Thoracic and Cardiovascular Surgery*. 2004;180-183.
5) Jenkins AL, Buist TAS, Glover SD. Medium-term follow-up of forty autogenous veins and forty (GoreTex) grafts for vascular access. *Surgery*. 1980;667- 672.
6) Huijbregts HJ, Blankestijn PJ. Dialysis access–guidelines for current practice. *European Journal Vascular Endovascular Surgery*. 2006;284-287.
7) Oto K. Vascular access, in Oxford Textbook of Clinical Nephrology (Vol 2) edited by Cameron S, Danison AM, Grünfeld JP, Kerr D, Ritl E. *Oxford, Oxford University Press*, 1992;1405-1417.
8) Schanzer H, Schanzer A. Vascular access for dialysis. In: Haimovici H, Ascer E, Hollier LH, editors. *Haimovici's Vascular Surgery. 5th ed. New York: Blackwell Publishing* 2004;1015-1029.
9) Acıpayam M, Zor H, Yıldız GR, Uncu H, Çetinoğlu M, Halıcı Ü, et al. Hemodiyaliz amaçlı açılan arteriyovenöz fistüllerin açıklığı üzerine etkili faktörler: Üç yıllık sonuçların değerlendirilmesi. *Turkish GKDC Magazine*. 2013;21:59-62.
10) Sidawy MA. Arteriovenous hemodialysis access. In: Rutherford RB, editor. *Vascular Surgery. Vol. 2, 6th ed. Philadelphia. Elsevier Saunders*: 2005;1669-1706.
11) Tedoriya T, Urayama H, Katada S, Watanabe Y. A survey of vascular access for hemodialysis. *Journal of Vascular Surgery*. 1995;29:123-127.
12) D'Ancona G, Karamanoukian HL, Ricci M, Schmid S,Bergsland J, Salerno TA. Graft revision after transit time flow measurement in off-pump coronary artery bypass grafting. *European Journal of Cardiothorac Surgery*. 2000;17:287-293.
13) Matre K, Birkeland S, Hessevik I, et al. Comparison of transit time and Doppler ultrasound methods for measurement of flow in aortocoronary bypass grafts during cardiac surgery. T*horac Cardiovascular Surgery*. 1994;42-45.

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