

Study of arteriovenous fistula function by the temperature gradient method using the Twister™ device

Ramon Roca-Tey, Rosa Samon, Omar Ibrik, Amparo Roda, Juan C. González-Oliva, Jordi Viladoms

Servicio de Nefrología. Hospital de Mollet. Mollet del Vallès, Barcelona (Spain)

Nefrologia 2012;32(2):172-9

doi:10.3265/Nefrologia.pre2012.Jan.11132

ABSTRACT

Introduction. Periodic blood flow (Q_A) measurement is the preferred way for arteriovenous fistula (AVF) surveillance in chronic hemodialysis (HD) patients. **Objectives.** 1) Assess the efficacy of the temperature gradient method (TGM) on the Q_A determinations using the Twister™ device and to compare the functional results with the Delta-H method. 2) Evaluate the effect of blood pressure on the AVF function. **Patients and method.** We measured the Q_A non invasively in 30 AVF (24 radial and 6 brachial; mean duration 53.4±78.5 months) during HD in 30 stable patients (mean age 59.9±14.1 years, males 60 %, females 40 %; mean time on HD 37.4±40.6 months, diabetic nephropathy 20 %) by the TGM, described and validated by Wijnen et al (Kidney Int 2007;72:736). The Q_A was calculated from the temperature values obtained by means of the blood temperature monitor (BTM), integrated into the Fresenius Medical Care 4008-S machine, at normal and reverse configurations of the HD blood lines, with no need for a thermal bolus. The Twister™ device was used for reversing the blood lines without the need to disconnect them from the AVF lines nor to stop the blood pump. The Q_A was measured within the first hour of two consecutive HD sessions (the values were averaged). The mean arterial pressure MAP (diastolic pressure + 1/3 pulse pressure) was calculated simultaneous with the Q_A . In addition, the AVF blood flow was also determined during the same week in all patients by the Delta-H method using the Crit-Line III Monitor (ABF-mode, HemaMetrics, USA) during HD (manually switching lines). **Results.** The mean Q_A was 1132.5±515.4 ml/min (range, 446-2233 ml/min). The mean

coefficient of variation for duplicate Q_A measurements was 6.8±4.7 %; the MAP was not different when the reproducibility tests were performed (96.1±13.7 versus 96.6±12.8 mmHg, $p=.72$). No significant difference was found when comparing the mean Q_A between diabetic ($n=6$, 966.4±340.7 ml/min) and nondiabetic ($n=24$, 1174.4±548.3 ml/min) patients ($p=.39$). The mean Q_A was similar for patients with mean MAP < 100 mmHg ($n=18$, 1101.0±552.7 ml/min) and for patients with mean MAP ≥ 100 mmHg ($n=12$, 1180.4±473.3 ml/min) ($p=.69$). No correlation was found between the mean Q_A and: age ($r=0.09$, $p=.62$), time on HD ($r=0.06$, $p=.76$), MAP ($r=-0.21$, $p=.27$), Kt/V index ($r=0.12$, $p=.51$), distance between needles ($r=-0.17$, $p=.37$) and AVF duration ($r=-0.01$, $p=.96$). The mean time required to measure Q_A with the TGM using the Twister™ device (5.9±1.9 min) was significantly shorter compared with the Delta-H technique (26.8±1.9 min) or with the TGM (manually reversing lines) reported by Wijnen et al (Kidney Int 2007;72:736.) (for both comparisons, $p < .001$). The mean Q_A obtained by the TGM was not different when compared to mean ABF determined by the Delta-H method (1138.4±502.3 ml/min) ($p=.83$). The calculated values of AVF blood flow obtained by TGM were highly correlated with those determined by the Delta-H technique ($r=0.963$, $p < .001$). **Conclusions.** 1) The TGM is a valuable and reproducible indicator of Q_A during HD. 2) The Twister™ device is useful to reduce the time for Q_A measurement by the TGM. 3) The AVF blood flow values obtained by the TGM and the Delta-H technique correlated highly with each other. 4) It has been shown the lack of relationship between the AVF function and the patient's blood pressure.

Correspondence: Ramón Roca Tey
Tamarit 144-146, 3º 3ª.
08015-Barcelona, Spain
18647rrt@comb.cat
r.roca@hospitalmollet.cat

Keywords: Arteriovenous fistula. Vascular access blood flow monitoring. Temperature gradient method. Twister™ device. Delta-H method. Blood pressure.

Estudio de la función de la fistula arteriovenosa mediante la técnica de gradiente de temperatura y utilizando el dispositivo Twister®

RESUMEN

Introducción: La determinación periódica del flujo sanguíneo (Q_A) es el método de elección para monitorizar la fistula arteriovenosa (FAVI) de los pacientes en hemodiálisis (HD) crónica. **Objetivos:** 1) Valorar la eficacia de la técnica de gradiente de temperatura (TGT) en la determinación de Q_A utilizando el dispositivo Twister® y comparar los resultados funcionales con el método Delta-H. 2) Analizar el efecto de la presión arterial sobre la función de la FAVI. **Pacientes y método:** Hemos determinado no invasivamente el Q_A de 30 FAVI (24 radial y 6 humeral; duración media 53,4±78,5 meses) en 30 pacientes (edad media: 59,9±14,1 años; sexo H: 60%, M: 40%; tiempo medio en HD: 37,4±40,6 meses; nefropatía diabética: 20%) estables durante la HD mediante la TGT, descrita y validada por Wijnen et al. (Kidney Int 2007;72:736). El Q_A se calculó a partir de los valores de temperatura obtenidos mediante el monitor de temperatura sanguínea BTM, integrado en la máquina Fresenius Medical Care 4008-S, con las líneas sanguíneas de HD en configuración normal e invertida, y sin la necesidad de generar un bolus de temperatura. El dispositivo Twister® se utilizó para revertir las líneas sanguíneas sin necesidad de desconectarlas de las agujas ni de detener la bomba sanguínea. El Q_A se determinó durante la primera hora de 2 sesiones consecutivas de HD (ambos valores se promediaron). La presión arterial media (PAM) (presión diastólica + 1/3 de la presión del pulso) se calculó simultáneamente con el Q_A . Paralelamente, el flujo sanguíneo de la FAVI se determinó durante la misma semana en todos los pacientes mediante el método Delta-H utilizando el monitor Crit-Line III (HemaMetrics, USA) durante la HD (inversión manual de las líneas). **Resultados:** El Q_A medio fue 1132,5±515,4 ml/min (intervalo, 446-2233 ml/min). El coeficiente de variación para medidas duplicadas de Q_A fue 6,8±4,7%; la PAM no influyó en la reproductibilidad de la TGT (96,1±13,7 vs. 96,6±12,8 mmHg, $p=0,72$). Sin diferencias al comparar el Q_A de pacientes diabéticos ($n=6$, 966,4±340,7 ml/min) y no diabéticos ($n=24$, 1174,4±548,3 ml/min) ($p=0,39$). El Q_A fue similar tanto para los pacientes con PAM<100 mmHg ($n=18$, 1101,0±552,7 ml/min) como para los pacientes con PAM ≥ 100 mmHg ($n=12$, 1180,4±473,3 ml/min) ($p=0,69$). No hemos objetivado ninguna correlación entre el Q_A medio y: edad ($r=0,09$, $p=0,62$), tiempo en HD ($r=0,06$, $p=0,76$), PAM ($r=-0,21$, $p=0,27$), índice Kt/V ($r=0,12$, $p=0,51$), distancia entre las agujas ($r=-0,17$, $p=0,37$) y duración de la FAVI ($r=-0,01$, $p=0,96$). El tiempo medio empleado para determinar el Q_A por la TGT utilizando el accesorio Twister® (5,9±1,9 min) fue significativamente inferior en relación con el método Delta-H (26,8±1,9 min) o con la TGT ($n=35$, 8,9±3,5 min, inversión manual de las líneas) aplicada por Wijnen et al. (Kidney Int 2007;72:736) (para ambas comparaciones, $p<0,001$). El Q_A medio obtenido mediante la TGT fue similar al flujo sanguíneo medio determinado con el método Delta-H (1138,4±502,3 ml/min) ($p=0,83$). Los valores

del flujo sanguíneo de la FAVI obtenidos mediante la TGT se correlacionaron significativamente con los determinados por el método Delta-H ($r=0,963$, $p<0,001$). **Conclusiones:** 1) La TGT es un método válido y reproducible para calcular el Q_A durante la HD. 2) El dispositivo Twister® es eficaz para reducir el tiempo empleado en determinar el Q_A mediante la TGT. 3) Los valores de flujo sanguíneo de la FAVI obtenidos mediante la TGT y el método Delta-H se correlacionaron significativamente. 4) Se ha evidenciado una independencia entre la función de la FAVI y la presión arterial del paciente.

Palabras clave: Fistula arteriovenosa. Flujo sanguíneo de la vena arterializada. Técnica de gradiente de temperatura. Dispositivo Twister®. Método Delta-H. Presión arterial.

INTRODUCTION

Thrombosis is the most common complication in permanent vascular accesses (VA) such as arteriovenous fistulas (AVF) and polytetrafluoroethylene grafts.¹ To prevent it and therefore reduce catheter use among prevalent patients on chronic haemodialysis (HD), we must develop structured programmes for VA surveillance in the HD units.² In addition to addressing non-anatomical causes of thrombosis, these programmes consider the use of different screening methods for early diagnosis of significant VA stenoses associated with elective corrective procedures such as angioplasty and/or revision surgery.¹⁻³

According to the latest version of the KDOQI guidelines, non-invasive screening methods based on indirect measurement of the VA blood flow (Q_A) are the methods of choice for regular VA surveillance.¹ Since 1995, it has been described several of these methods and some of them have subsequently applied in daily clinical practice, such as ultrasound dilution, Delta-H or thermodilution.⁴ Some of these techniques have been proven effective in providing an early diagnosis of significant stenosis and reducing the rate of VA thrombosis.^{5,6}

The temperature gradient method (TGM) was described and validated by Wijnen et al in 2007 by comparison against the ultrasound dilution method.⁷ This method allows us to calculate the Q_A from the temperature values obtained by means of the blood temperature monitor (BTM) with the HD blood lines in the normal and reversed positions.⁷ The use of a specialised device named Twister™ (Fresenius Medical Care), which is placed between the HD needles and the blood lines, can simplify the Q_A determination by shortening the time needed to reverse the HD blood lines (Figure 1).

On the other hand, no reliable study on VA function can overlook a variable as important as the patient's blood



Figure 1. The Twister™ device Twister™ device before (right) and after (left) placement during a hemodialysis session with the blood lines in the normal (above) and reversed (below) positions.

pressure. In this regard, some authors have highlighted the direct relationship between the mean arterial pressure (MAP) and the Q_A of the VA, meaning that changes in the MAP can affect the VA function.^{8,9}

This is an observational, cross-sectional, comparative study of the TGM with the following objectives:

- 1) Evaluate TGM efficacy in measuring the Q_A at the AVF during HD.
- 2) Determine whether placement of the Twister™ shortens the time needed to determine Q_A .
- 3) Undertake a comparative functional study of TGM and the Delta-H method.
- 4) Analyse the effect of blood pressure on AVF function.

MATERIAL AND METHOD

Patients

The AVF was evaluated in 30 patients undergoing HD 3 times weekly in the Nephrology Department at Hospital de Mollet. Inclusion criteria for patients were as follows: 1) Age >18 years. 2) In chronic HD programme. 3) Use of the AVF as a permanent VA. 4) Puncture of the AVF with 2 needles during a minimum of 12 consecutive HD sessions. 5) Use of a Q_B greater than 250ml/min during a minimum of 12 consecutive HD sessions. 6) Informed consent from the patient. The following variables were analysed: sex, age, time on HD, diabetic nephropathy as a cause of renal failure,

Kt/V index (by Daugirdas second-generation single-pool model), MAP (diastolic blood pressure +1/3 pulse pressure), type of AVF, duration of AVF, total number of VA and distance between needles. Table 1 summarises the most important clinical characteristics of the patients included in the study.

Method

1) Measuring the Q_A by means of TGM. The Q_A was measured by using the BTM sensor incorporated in the 4008 S machine manufactured by Fresenius Medical Care. TGM allows us to calculate the Q_A from the temperature values obtained with the HD blood lines in the normal and reverse positions, with no need for creating a bolus of temperature. The Q_A was calculated using the following formula:

$$Q_A = (Q_{B,x} - UFR) \cdot \frac{T_{art,x} - T_{ven,x}}{T_{art,n} - T_{art,x}}$$

Where $Q_{B,x}$ is the effective blood flow with blood lines in reverse position (ml/min), UFR is the ultrafiltration rate (ml/min), $T_{art,n}$ is the temperature of the arterial line with blood lines in normal position, $T_{art,x}$ is the temperature of the arterial line with blood lines in reverse position, and $T_{ven,x}$ is the temperature of the venous line with blood lines in reverse position. To correctly calculate the Q_A , the Q_B , the UFR and the dialysate temperature (35.5°C) must remain constant throughout the entire measurement process⁷. The Q_A was calculated twice during the first hour of 2 consecutive HD sessions, and these two values were weighed. The MAP was also measured also in both HD sessions along with the Q_A .

2) Twister™ device. This accessory measuring 37.5cm in length has a dial-shaped rotating mechanism in its centre. On

Table 1. Characteristics of patients and AVF studied using TGM

Sex (%)	Men: 60 / Women: 40
Average age (years)	59.9±14.1 (range: 20-83)
Mean time on HD (months)	37.4±40.6 (range: 2-150)
Diabetic nephropathy (%)	20 (6/30)
Kt/V index	1.48±0.17 (range: 1.19-1.84)
Type of AVF (%):	Forearm: 80/ Upper arm: 20
Mean duration of AVF (months)	53.4±78.5 (range: 2-299)
Patients with prior VA (%)	33.3 (10/30)
VA/patient ratio	1.57±1.10
Distance between needles (cm)	6.02 ± 2.32 (range: 3-13)

VA: vascular access; HD: haemodialysis; AVF: internal arteriovenous fistula; TGM: temperature gradient method

1 side it connects to the blood lines, and on the other side, to the 2 needles puncturing the AVF. By simply rotating the mechanism (turning the dial halfway), the blood lines reverse flow direction automatically with no need for disconnecting them from the needles or stopping the haemodialysis pump. At the end of the procedure, turning the dial once more in the opposite direction will instantly re-establish the normal flow direction of the blood lines (Figure 1).

3) Measuring the Q_A by the Delta-H method. During the same week, the Q_A was calculated using the Delta-H optodilution method using the Crit-Line III monitor (ABF-mode, HemaMetrics, USA) in all patients. This method, described and validated by Yarar et al¹⁰ is a photometric technique based on the inverse relationship existing between volaemia and haematocrit (Hct). The Q_A was also determined during the first hour of the HD session based on the changes recorded in Hct and the scheduled changes in ultrafiltration (from 0.1 to 1.8l/h) with blood lines in normal and reversed positions. Changes in Hct were registered continuously by an optical sensor coupled to a blood chamber inserted between the dialyser and the arterial line. Q_A was calculated using the following formula:

$$Q_A = (UF \text{ max.} - UF \text{ min.}) \cdot Hct \text{ max. rev.} / \Delta Hct \text{ rev.} - \Delta Hct \text{ nor.}$$

Where UF max. is maximum ultrafiltration rate, UF min. is minimum ultrafiltration rate, Hct max. rev. is maximum Hct with blood lines in reverse position, ΔHct rev. is the change in Hct with the lines reversed and ΔHct nor. is the change in Hct with blood lines in normal position. Reversing the blood lines was performed manually after momentarily stopping the haemodialysis pump (the Twister™ device was not used).

Statistical study

Statistical analysis of the data was performed using the SPSS program version 12.0 for Windows. Values were expressed as percentages or mean±standard deviation. The mean coefficient of variation for duplicate Q_A measurements was calculated by averaging the quotient of the standard deviation and the mean of the two measurements taken for each patient. The comparative study between the mean Q_A obtained and the variables specific to both the patient and the AVF, compared 2 by 2, was performed using Student's t-test for 2 independent samples and the non-parametric Mann-Whitney U test. Pearson's correlation coefficient was calculated to analyse the correlation between the mean Q_A at the AVF and the different quantitative variables studied.

The time required to determine Q_A was calculated as follows, depending on the method used:

- 1) TGM: Time needed to record the temperature of the arterial line, which are necessary in order to calculate Q_A ,

as shown on the BTM display upon beginning the examination, with blood lines in the normal position + time needed for instant reversal of blood lines by using the Twister™ device + time to stabilise temperature with blood lines in the reversed position (time needed in order to maintain exactly the same temperature during a minimum of 1 minute) + time to record the temperature values shown on the BTM display, which are necessary in order to calculate Q_A (blood lines in reverse position) + time to automatically revert blood lines to normal blood flow direction using the Twister™ device. Unlike when the Delta-H method is used, the Q_A value is not obtained automatically. It must be calculated after completing the examination, using the formula described above.

- 2) Delta-H method: time elapsed during the first part of the examination, when the measured haematocrit values in relation to scheduled changes in ultrafiltration are automatically recorded, with blood lines in the normal position + time to stop the haemodialysis pump + time to manually invert the blood lines + time to re-start the HD pump + time elapsed during the second part of the examination, when the measured haematocrit values in relation to scheduled changes in ultrafiltration are automatically recorded with blood lines reversed + time to record the Q_A value displayed on the Crit-Line III monitor + time to stop the HD pump + time to manually revert the blood lines to their normal position + time to re-start the haemodialysis pump.

We completed a correlation analysis of the AVF blood flow values measured by Delta-H and by the TGM in the same patient sample. The Bland-Altman graph was drawn so as to provide a visual display of concordance between the two methods. *P* values <0.05 were considered to be statistically significant.

RESULTS

The mean Q_A at the AVF obtained by TGM was 1132.5±515.4ml/min (range: 446-2233ml/min). The coefficient of variation for duplicate Q_A measurements was 6.8±4.7%. Table 2 shows the mean values of Q_A and MAP measured in the 2 consecutive HD sessions. There are no differences between MAP values taken in the first and second sessions (*P*=not significant).

No differences were found when comparing the mean Q_A in relation to variables of the patient and the AVF shown in Table 3. The Q_A from the AVF of diabetic patients was less than 1000 ml/min, but this was not significantly different compared to the remaining patients. The mean Q_A was similar when comparing patients with MAP above or below 100 mmHg. The brachial AVF showed a higher mean Q_A than the radial AVF, but the difference was not statistically significant. We observed no correlations

between mean Q_A and: age ($r=0.09$, $P=.62$), time on HD ($r=0.06$, $P=.76$), MAP ($r=-0.21$, $P=.27$), Kt/V index ($r=0.12$, $P=.51$), distance between needles ($r=-0.17$, $P=.37$) or AVF duration ($r=-0.01$, $P=.96$).

Table 2. Q_A and MAP values taken during 2 consecutive haemodialysis sessions

Measurement	Q_A (ml/min)	MAP (mmHg) ^a
First	1107.3±507.3	96.1±13.7
Second	1158.2±528.8	96.6±12.8
Mean	1132.5±515.4	96.1±12.5

^a $P=.72$. Q_A : blood flow; MAP: mean arterial pressure

The mean time to obtain the temperature values needed to calculate the Q_A by the TGM using the Twister™ device, was 5.9±1.9 minutes (range 2-11 minutes) and significantly lower in relation to the Delta method -H applied in this study (Table 4). As shown by the histogram in Figure 2, the time required in most cases (46/60, 76.7%) using TGM ranged between 4 and 7 minutes.

Mean Q_A calculated by using the TGM (1132.5±515.4ml/min) was similar to that measured using the Delta-H method (1138.4±502.3ml/min) ($P=.83$). As shown in the histogram in Figure 3, the absolute difference between mean Q_A values at the AVF taken using both measurement methods was less than 150ml/min in 66.7% of the patients (20/30). Blood flow values at the AVF measured using TGM showed a significant correlation with those taken using the Delta-H method

Table 3. Relationship between the obtained Q_A and the variables from the patient and the AVF

VARIABLE	no.	Mean Q_A (ml/min)	P
Sex			
Men	18	1090.6±436.5	
Women	12	1196.0±631.2	.59
Age (years)			
<65	20	1093.0±451.1	
≥65	10	1212.3±644.8	.56
Time on HD (months)			
<36	20	1144.8±568.8	
≥36	10	1108.7±414.6	.86
Diabetic nephropathy			
Yes	6	966.4±340.7	
No	24	1174.4±548.3	.39
Kt/V index			
<1.40	9	1081.3 ±540.9	
≥1.40	21	1154.8±516.1	.73
MAP (mmHg)			
<100	18	1101.0±552.7	
≥100	12	1180.4±473.3	.69
Type of AVF			
Forearm	24	1080.4±440.3	
Upper arm	6	1342.2±763.4	.45
AVF duration (months)			
<36	19	1087.5±513.0	
≥36	11	1211.0±519.2	.54
Total No. VA			
1	20	1035.8±469.6	
>1	10	1326.6±572.4	.15
Distance btw needles (cm)			
<6	17	1282.0±637.6	
≥6	13	1020.4±430.3	.23

VA: vascular access; AVF: internal arteriovenous fistula; HD: haemodialysis; MAP: mean arterial pressure; Q_A : blood flow.

($r=0.963$, $P<.001$) (Figure 4). The Bland-Altman graph in Figure 5 shows concordance between both screening methods, even where mean Q_A values are equal to or above 2000ml/min ($n=3$).

DISCUSSION

TGM has been proven an effective means of evaluating AVF function. The Q_A value obtained by TGM in this study coincides with previously reported values obtained by other non-invasive screening methods for measuring Q_A .^{3,11-15} In addition, the Q_A result reported in the TGM validation cohort study carried out by Wijnen et al (1000±588ml/min) is very similar to the Q_A calculated in our study.⁷

In this study, TGM demonstrated optimal reproducibility with a coefficient of variation for duplicate Q_A measurements

of less than 10%. This result allows the TGM’s reproducibility to be compared favourably to that of other methods used in daily clinical practice, such as the Delta-H or ultrasound dilution methods.^{3,16}

Our study found a significant functional correlation between the Delta-H method, which is routinely used in our department, and the TGM. Comparison of Q_A values at the AVF obtained by both methods revealed no differences. The previously mentioned cohort study by Wijnen et al also reported a significant correlation ($r=0.964$, $P<.05$) between Q_A values obtained using the ultrasound dilution method (mean Q_A 960±594ml/min) and TGM.⁷ Therefore, considering their efficacy in obtaining reliable Q_A values, the TGM and Delta-H methods are equivalent and can be used interchangeably for regular VA monitoring.

Time is money, especially when we consider the current dynamics in many HD units in Spain. Therefore, if we are to

Table 4. Required time to calculate the Q_A using three methods for AVF surveillance

Method used	No. patients	No. measurements	Line reversal	Time required (min)
TGM (current study)	30	60	Twister™	5.9±1.9
Delta-H (current study) ^a	30	30	Manual	26.8±1.9
TGM (Wijnen et al, 2007) ^b	35	70	Manual	8.9±3.5
Thermodilution (Wijnen et al, 2006) ^c	40	60	Manual	29±7

^a TGM (current study) vs Delta-H (current study); $P<.001$.

^b TGM (current study) vs TGM (Wijnen et al, 2007); $P<.001$.

^c TGM (current study) vs thermodilution (Wijnen et al, 2006); $P<.001$.

AVF: internal arteriovenous fistula; Q_A : blood flow; TGM: temperature gradient method

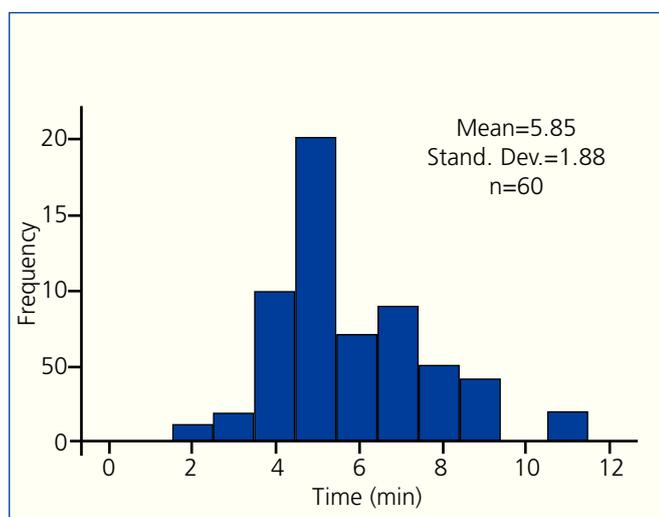


Figure 2. Time needed to calculate Q_A using TGM. Q_A : blood flow; TGM: temperature gradient method.

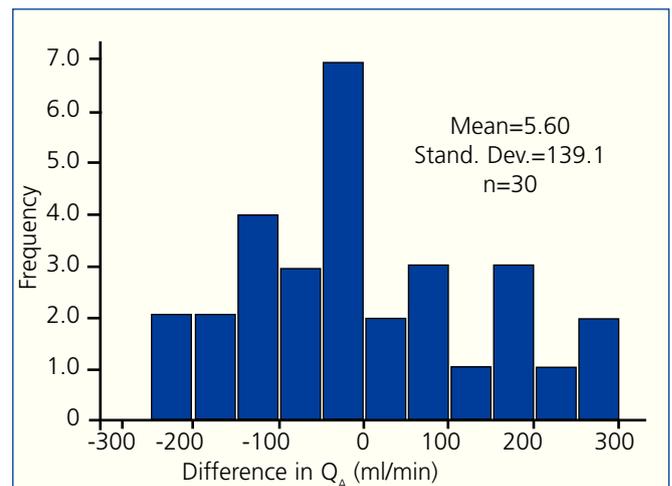


Figure 3. Absolute difference between mean Q_A obtained by TGM and by Delta-H. Q_A : blood flow; TGM: temperature gradient method.

ensure the success of the VA surveillance programs, we must to apply a quick method for VA monitoring in the HD room without excessive consumption of time. In this regard, the joint application of the TGM and the Twister™ device allows to obtain the data necessary to calculate the Q_A of the AVF in significantly less time compared to the Delta-H method (current study) and to the methods that used the BTM to determine the Q_A such as the thermodilution method and the same TGM with manual switching of HD lines (Table 4).^{7,17}

The direct relationship between the MAP and the Q_A of the AVF is well-known, and it is expressed as follows: $Q_A = \text{MAP} - \text{central venous pressure} / \text{AVF resistance}$ ¹⁸. For example, in the multivariate study from Tonelli et al including 4084 Q_A measurements by ultrasound dilution in 294 patients with AVF, it was observed that for each 1 mmHg of increase in systolic blood pressure, the Q_A increased by 1.8 and 2.9 ml/min in distal and proximal AVF, respectively¹⁹ Consequently, the results from any study examining AVF function cannot be valid unless they consider blood pressure. The current study analysed the effect of MAP on two fundamental aspects:

- 1) Reproducibility of the TGM. No differences were found when comparing the MAP values obtained simultaneously with the first and second Q_A measurements. Therefore, the patient's blood pressure did not interfere with the study of the TGM reproducibility.
- 2) The Q_A of the AVF. No correlations were found between the MAP and the Q_A of the AVF, even when MAP values higher or lower than 100 mmHg are considered separately.

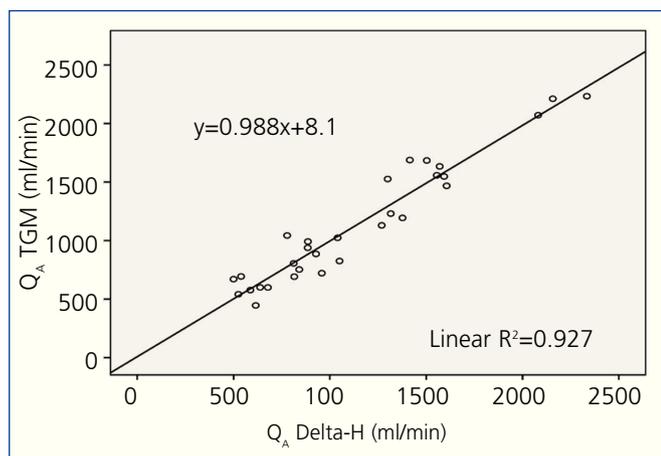


Figure 4. Correlation between Q_A values at the AVF obtained by TGM and by Delta-H (n=30)

AVF: internal arteriovenous fistula; Q_A : blood flow; TGM: temperature gradient method.

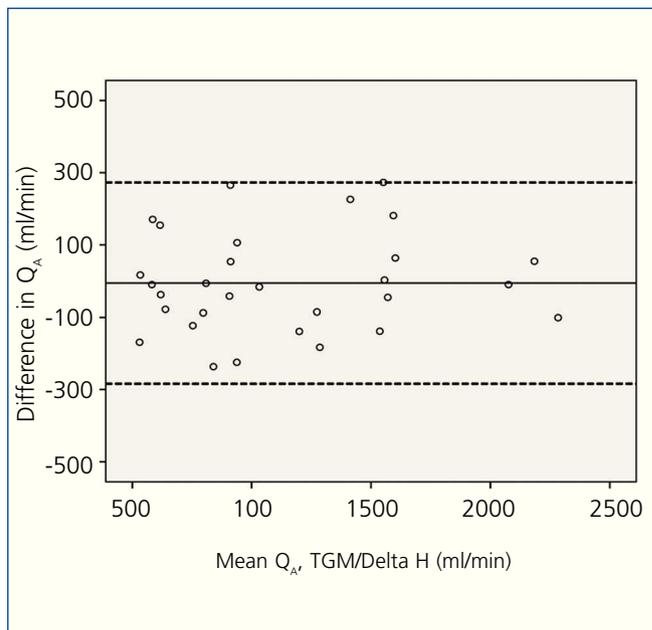


Figure 5. Bland-Altman graph representing the relationship between mean Q_A obtained by TGM and by Delta-H. (n=30) Q_A : blood flow; TGM: temperature gradient method.

Therefore, it has shown a total independence between the AVF function (assessed objectively by calculating the Q_A) and the MAP in the current study. This result may be explained by the fact that Q_A measurements were made at the beginning of the HD session, when blood pressure was stable, avoiding subsequent drops in blood pressure secondary to the ultrafiltration scheduled.

In this regard, according to Rehman et al., the MAP is the main factor that determines the Q_A variations during HD so that, after 90 minutes of the start of the HD session, for every 10% decrease in the MAP, the Q_A is reduced by 8%.²⁰

In summary, the main objective of the VA surveillance programs in the HD units is to prevent thrombosis in prevalent patients. To do this, you must have in the HD room an objective screening method of simple application that allows us to know the AV function reliably in the shortest time possible. The TGM associated with Twister™ device meets all these requirements and can help us achieve the goal of reducing the current rate of VA thrombosis.

Acknowledgements

We would like to thank Fresenius Medical Care for providing the Twister™ device.

Conflicts of interest

The authors affirm that they have no conflicts of interest related to the content of this article.

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