

*Original Article*

## Cannulating in haemodialysis: rope-ladder or buttonhole technique?

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### Abstract

**Background.** The standard technique for fistula cannulation, the rope-ladder technique, is problematic for patients with short fistula lengths and for patients in whom the fistula is difficult to cannulate. The buttonhole technique, cannulation of exactly the same site, offers the advantage of an easy cannulation procedure. However, it can be used only in native fistulas and cannulation is preferably executed by a ‘single-sticker’. This study was conducted to compare these cannulation techniques using objective parameters.

**Methods.** We introduced the buttonhole technique for self-cannulating home haemodialysis patients and compared it with baseline data obtained with the rope-ladder technique. Thirty-three patients with a native arteriovenous fistula were observed prospectively during 18 months on the following parameters: cannulating ease, number of bad sticks, pain, time of compression after cannula removal, bleeding, infectious complications and aneurysm formation.

**Results.** With the buttonhole method, cannulating ease improved distinctly, which was especially favourable in patients with a short fistula vein. Reported cannulation pain did not change significantly. The incidence of bad sticks decreased significantly, as well as time of compression after cannula removal, without increased incidence of bleeding. Three patients developed a local skin infection of their buttonhole during the study, after which the disinfection routine prior to cannulation was changed.

**Conclusions.** Compared with the rope-ladder technique, the buttonhole method offers the advantage of an easier cannulation procedure with less bad sticks, which has a special benefit for patients with limited access cannulation sites or with a fistula which is difficult to cannulate. Prolonged compression times or re-bleeding episodes did not occur, but precautions have to be taken in order to prevent infectious complications. The buttonhole method can contribute considerably to the cannulating ease of self-cannulating patients, thus providing a better quality of life.

**Keywords:** buttonhole technique; cannulation in haemodialysis; rope-ladder technique; self-cannulation; vascular access

### Introduction

Adequate vascular access is an essential factor in successful haemodialysis [1], and it has a major effect on the quality of life of haemodialysis patients [2–4]. Patients claim that they experience less pain with self-cannulation than with cannulation by a haemodialysis nurse. However, little is known about the influence of puncturing methods on patients’ experience.

In The Netherlands, haemodialysis nurses and self-cannulating haemodialysis patients are trained to use the entire length of an arteriovenous fistula or graft for puncturing (rope-ladder technique), in order to prevent aneurysm formation [5]. However, in daily clinical practice, often the same area of the fistula or graft is cannulated for reasons of comfort and ease. This may lead to aneurysmatic dilatations of the puncture areas and stenoses in adjacent regions. An alternative method is the ‘constant-site’ method of cannulation, or ‘buttonhole’ technique [6–9]. With this method, cannulas are inserted at exactly the same spot at consecutive dialysis sessions, thus developing a channel in the arteriovenous fistula. This technique is probably not suitable for arteriovenous grafts, because of the fragile wall and higher pressures. The aim of our study was to investigate prospectively the effects of the buttonhole puncture technique in self-cannulating patients on ease and incidence of adverse events. A within-patient comparison was done with the results of the previously used rope-ladder puncture technique.

### Subjects and methods

From July 2004 to January 2006, 33 patients on home haemodialysis were included. Inclusion criteria were the presence of a native arteriovenous fistula, either at the wrist or the elbow, and the ability to perform self-cannulation of

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the fistula. Exclusion criteria were recent fistula occlusion, high venous pressure, and presence of extensive fistula aneurysms. Included were patients with difficult cannulation procedures due to the following:

- anatomical characteristics of the fistula (tortuosity, haematomas, a short length for cannulation);
- frequent bad sticks;
- a stressful and/or painful cannulation procedure.

At baseline, all patients were using the rope-ladder technique. To identify an optimal buttonhole site, preferably a straight, infrequently used section of the fistula was chosen, that was easily accessible for self-cannulation [10]. Patients were instructed to establish a buttonhole in their fistula according to the following guidelines:

- remove the scab from the puncture site, using an aseptic needle or a disinfected splinter forceps;
- clean the surface of the fistula with ethanol;
- keep the fistula-arm in exactly the same position at every cannulation;
- cannulate the fistula always at the same angle ( $\pm 25^\circ$ ), decrease the angle of insertion as soon as blood flashback is observed;
- securely fixate the cannula with tape.

During the break-in period (the period necessary to establish a good puncture site) sharp cannulas were used. After the break-in period, patients on double-needle dialysis were encouraged to use blunt cannulas (AVF 15G, Nipro Corporation, Osaka, Japan). For single-needle dialysis, no blunt cannulas were available in the Netherlands, so they could not be tested.

Cannulation was supervised by a nurse specialized in home haemodialysis, who visited and contacted the patient on a regular basis.

The following parameters were registered at baseline and at 1.5, 3, 6, 12 and 18 months after inclusion: cannulation ease, bad sticks (i.e. need for repeated insertion), pain, compression time after cannula removal, oozing of blood alongside the cannula, re-bleeding of the puncture site after compression, signs of infection, aneurysm formation and thrombosis; cannulating ease and pain during the previous two weeks were scored by the patients on a visual analogue scale (VAS-score); incidence of bad sticks, oozing and re-bleeding were registered as the absolute number of these events during the last two weeks of the different follow-up periods.

Data on the incidence of infection, aneurysm formation and thrombosis were recorded by the nurse by direct observation and review of patient charts. In addition, the home haemodialysis nurse scored her assessment of the buttonhole technique regarding cannulating ease and cosmetic appearance of the fistula.

Data of the rope-ladder technique were obtained at baseline. The data of the buttonhole technique, obtained during the 18 months of follow-up, were averaged and compared with the baseline data.

Statistical analysis was performed by SPSS for Windows, software version 12.0 (SPSS Inc., Chicago, USA). Results are expressed as mean  $\pm$  SD, or median with range when appropriate. Paired Student's *t*-test was used to compare follow-up data with baseline data. Differences were considered significant at  $P < 0.05$ .

## Results

### *Patients and vascular access*

We included 24 men and 9 women, aged  $49 \pm 13$  years, who were on renal replacement therapy for 24 (2–384) months. All patients were able to perform self-puncturing. Arteriovenous fistulas were distal forearm fistulas ( $n = 24$ ) and proximal forearm fistulas ( $n = 9$ ), created  $> 6$  months ( $n = 27$ ) or  $\leq 6$  months ( $n = 6$ ) before inclusion. Fifteen patients were included because of a short length of cannulation and other anatomical criteria; 18 because of frequent bad sticks, extreme cannulating stress or a painful cannulation procedure. Haemodialysis frequency was, per week, 3–4 times (double-needle,  $n = 11$ ), 5–7 times (single-needle,  $n = 13$ ) or 6–7 times nocturnal (single-needle,  $n = 9$ ). Most patients used steel cannulas, catheter cannulas were used by only three patients; cannula placement was centripetally [7]. Mean duration of follow-up was  $11 \pm 6$  months, covering 7090 dialysis sessions.

In general, the break-in period lasted 2–3 weeks, depending on the stability of the cannulating technique and the number of dialysis sessions per week. All patients established two or three buttonholes, so as not to use a buttonhole more frequently than 3–4 times a week. Of the 11 patients who could test the blunt cannulas, only three patients made a serious attempt, the others were reluctant because of the different cannulation technique required. Therefore, not enough data are available to formulate a conclusion about blunt cannulas.

### *Cannulation results*

Compared with the rope-ladder technique, the buttonhole technique showed a significant improvement of cannulating ease: the VAS-score decreased from  $2.9 \pm 2.4$  at baseline to  $1.3 \pm 1.2$  ( $P = 0.002$ ) during follow-up on a scale from zero ('no problem at all') to 10 ('too hard to cope with'). Cannulating ease kept improving after 3 and 6 months (Table 1). The small group of patients that suffered from extreme cannulating stress with the rope-ladder technique ( $n = 5$ ) benefited most from the buttonhole method: cannulation ease score improved from  $6.7 \pm 2.0$  to  $1.0 \pm 0.8$  ( $P = 0.03$ ).

The incidence of bad sticks decreased significantly with the buttonhole method from  $0.8 \pm 1.4$  to  $0.3 \pm 0.6$  incidents per 2 weeks ( $P = 0.03$ ), but the absolute frequency was low in general.

Less cannulation pain was experienced at 6 weeks ( $P = 0.05$ ) and 3 months ( $P = 0.02$ ), but this effect was not consistent in the months thereafter. The average pain score using the buttonhole method was somewhat, but not significantly, less compared with the rope-ladder method (VAS-score on pain  $1.6 \pm 2.0$  with buttonhole and  $2.3 \pm 2.2$  with rope-ladder,  $P = 0.12$ ).

There was no increase in compression time, oozing of blood or bleeding of the puncture site (Table 1). During the follow-up period, we encountered three

**Table 1.** Within-patient comparison of the rope-ladder technique used at baseline and the buttonhole technique used during 18 months of follow-up

	Baseline (n = 32)	1.5 mo (n = 18)	3 mo (n = 14)	6 mo (n = 18)	12 mo (n = 11)	18 mo (n = 3)	Mean (1.5–18 mo)	P-value (baseline vs mean)
Cannulating ease <sup>a</sup>	2.9 ± 2.4	1.7 ± 1.9	1.5 ± 1.4	1.3 ± 1.0	1.0 ± 1.3	1.6 ± 1.5	1.3 ± 1.2	0.002
Cannulating pain <sup>a</sup>	2.3 ± 2.2	1.6 ± 2.0	1.5 ± 1.8	2.2 ± 2.0	1.0 ± 1.1	1.0 ± 1.7	1.6 ± 2.0	0.12
Bad sticks <sup>b</sup>	0.8 ± 1.4	0.4 ± 0.8	0.4 ± 0.6	0.4 ± 0.9	0.2 ± 0.6	0.0 ± 0.0	0.3 ± 0.6	0.03
Compression time (min)	8.7 ± 3.6	8.4 ± 3.8	7.9 ± 3.5	7.4 ± 3.8	7.7 ± 3.6		7.6 ± 4.0	0.004

Mo, months.

<sup>a</sup>Patient's score on the Visual Analogue Scale, from 0 ('no problem at all') to 10 ('too hard to cope with').

<sup>b</sup>Absolute incidence during the 2 weeks preceding the interview.

**Fig. 1.** Left forearm with arteriovenous fistula of a self-cannulating haemodialysis patient who used the buttonhole-technique for 5 years. Note the umbilical aspect of the buttonhole.

patients who developed a local skin infection of one of their buttonholes. No episodes of bacteraemia occurred in these patients and the infection was cured with oral antibiotics.

Aneurysms of the fistula did not develop during our study. In general, dilatation of the fistula was rare and could be halted by choosing another place for the buttonhole. Furthermore, existing aneurysms that had developed with the rope-ladder technique showed a tendency to flatten (Figure 1).

Thrombosis of the fistula was observed once after the patient used the buttonhole for 5 months, and a relation with the puncture technique is unclear. Thrombosis incidence was 1 in 31 years of dialysis, is 0.03/year.

According to the nurses, in 26 cases (79%) the use of the buttonhole method was considered a success, especially because of easier cannulation with less pain. The cosmetic effects of the buttonhole method, compared with the rope-ladder method, were considered favourable in 12 patients: less haematomas and less scar tissue were present compared with the rope-ladder technique; none of the patients suffered from negative cosmetic effects (Table 2).

## Discussion

Cannulation stress and fear of bad sticks certainly have a negative influence on the quality of life in

**Table 2.** Nurse's assessment on the buttonhole technique in the 33 patients

	Improvement	No change	Worsening
Cannulating ease	31	1	1
Cosmetic results	12	21	0
Overall results	26	6	1

haemodialysis patients. The only comparison of the buttonhole with the rope-ladder method is from Poland, published in 1979 [5]. Although this article described superior results with the buttonhole method, this method was not widely adopted for unclear reasons. Because of our experience in home haemodialysis and self-cannulating patients, our centre offered the ideal setting to study the buttonhole technique prospectively. Only self-cannulating patients were included to ensure the best possible chance of successful formation of buttonholes.

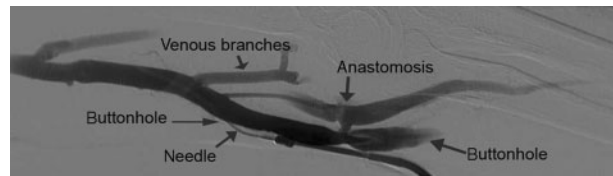
This study shows that cannulating ease and incidence of bad sticks improved markedly with the buttonhole technique. Especially the improvement in cannulating ease was considered important both by patients and nurses. Despite the relatively small numbers of patients, it is remarkable that we found significant within-patient changes on these issues. Due to the constant-site puncturing itself, causing a scar

tissue tunnel tract [10], one might expect some disadvantages, like longer compression time, blood leakage along the cannula, or re-bleeding after dialysis, but none of these occurred.

Although cannulating pain decreased during the first 3 months, there was no significant improvement in cannulating pain over all. However, when asked, patients claimed that pain had reduced markedly using the buttonhole method [11]. A possible explanation is that patients gave a too optimistic impression of their situation at baseline, reflecting their acceptance of cannulating pain [12]. The only negative outcome of the buttonhole technique is a possible larger incidence of skin infections. Therefore we accentuated our hygiene protocol as follows: (i) guarantee perfect hygiene by disinfecting the fistula twice: once before removing the scab and again after; (ii) carefully evaluate the puncturing technique of the patient: prevent forceful puncturing and friction of the cannula against the skin; (iii) prevent using the same buttonhole for more than three haemodialysis sessions/week, and preferably establish more than two buttonholes for single-needle and more than four buttonholes for double-needle dialysis and (iv) instruct the patient to recognize the beginning of infection, e.g. by means of a photo series. One could consider the use of mupirocine ointment, in order to prevent skin contamination with microorganisms.

The results were obtained in home haemodialysis patients performing self-cannulation, because they are pre-eminently able to cannulate exactly in the same way at every session. Probably, the results can be extrapolated to in-centre self-cannulating patients with an arteriovenous fistula, provided that they are supervised by nursing staff with training in the buttonhole method. Whether the method is suitable for cannulation by multiple cannulators is questionable [8,13]. If this is tried, the cannulators should be trained in inserting the cannula in exactly the same angle and way.

In conclusion, for self-cannulating patients the buttonhole technique can be a good alternative to the rope-ladder technique, especially in patients with frequent re-insertions, when a patient suffers from severe cannulating stress, or when the fistula provides too little space to use the rope-ladder technique (Figure 2). To prevent dilatation, a meticulous approach to form the buttonhole has to be followed. Furthermore, special measures are advocated to prevent infection of the fistula skin. The buttonhole technique is contraindicated in cases of poor eyesight, skin infections, poor cannulating technique, a fragile vascular wall, or in a fistula that is hard to stabilize during cannulation. Fear of bleeding or long compression times should not withhold a patient from trying the buttonhole technique, because these parameters were not negatively influenced.



**Fig. 2.** Angiogram of a proximal forearm fistula with two 1-year-old buttonholes. The angiogram was performed because of frequent bad sticks and inadequate arterial pressures; it revealed a  $\geq 50\%$  stenosis at the anastomosis. The patient refused percutaneous angioplasty, and since then she has been using the same buttonholes for 16 months without any complication.

In our opinion, all self-cannulating patients should start using the rope-ladder technique. When cannulating experience is obtained and the patient has been observed in technique and cannulating stress, the physician or nurse can make a balanced choice in advising the patient using either the buttonhole or the rope-ladder puncturing technique, with the arguments mentioned above. Under these conditions, the buttonhole method will certainly contribute to cannulating ease, thus improving the quality of life of self-cannulating patients.

*Conflict of interest statement.* None declared.

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