Does cannulation technique impact arteriovenous fistula and graft survival?

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Present professional position and workplace:
Director Nursing Care Management, Fresenius Medical Care Deutschland GmbH, NephroCare Coordination, Bad Homburg – Germany

Education / Past Experience:
Graduated in Nursing in 1974 and in Nursing Care Management in 1976 in Milan, Italy
Head Nurse in a Dialysis Unit in Milan, Italy
Marketing Director Peritoneal Dialysis, Fresenius Medical Care Italy.
Marketing Director Peritoneal Dialysis, Fresenius Medical Care Deutschland GmbH.

Summary of main areas of interest and experience:
• Vascular Access Cannulation and Care
• Dialysis processes analysis
• Safety in dialysis

Recent publications:
• Parisotto MT, et al. “Cannulation technique influences arteriovenous fistula and graft survival”. KI advance online publication 9 April 2014
• Co-editor of “Vascular Access Cannulation and Care – A Nursing Best Practice Guide for Arteriovenous Fistula”. Joint EDTNA/ERCA and Fresenius Medical Care project.
Preserving the AVF as the patient lifeline: reduced mortality with the AVF compared to Catheter

Vascular Access Major Cause of Hospitalisation

Complications Associated to VA Cannulation

Thrombosis 16.5%
Hemorrhage 7.5%
Infection 5.5%
Aneurysm 4.1%

% of VA cannulations

Yürügen and Erdogan, J Vasc Access 2001; 2: 119-124 (Data from Master Thesis at Istanbul University)
Preserving the Vascular Access is our responsibility
Phases of Vascular Access Management

- VA creation
- VA assessment and preparation
- VA cannulation
- VA monitoring during treatment
- VA disconnection
Vascular Access Cannulation: Study Design

- **Objective:**
  Snapshot on the current practice of vascular access cannulation

- **Design:**
  International, multi-centre, observational, cross-sectional survey

- **Centres:**
  Dialysis centres of the Fresenius Medical Care network in Europe, Middle East, Africa, participation on *voluntary basis*

- **Procedures:**
  Anonymous documentation of vascular access and its cannulation once per patient (Patient Questionnaire) at appointed date (April ‘09)
Vascular Access Cannulation: Inclusion criteria

- Patients treated with haemodialysis or haemodiafiltration during the week the survey was performed
- Vascular access via native fistula or graft
- Double needle haemodialysis
- No catheter, no single needle haemodialysis
Vascular Access Cannulation: Participating Countries and Centres

10 countries / 171 centres / 10,807 patients

(Numbers: Centres/Patients by country)
Results
Type of Vascular Access

- Fistula
- Graft
Location of Fistula

- Arm: 100%
- Leg: 0%
- Left: 70%
- Right: 30%
- Distal: 60%
- Proximal: 40%
- Missing/Not assessable: 10%
Cannulation Techniques

1. Rope ladder technique
2. Area technique
3. Buttonhole technique

- **Rope ladder:** 31.0%
- **Buttonhole:** 6.1%
- **Other/missing:** 1.8%
- **Area:** 61.0%
Needles & Cannulation Procedure

- **Needle type**: Sharp
- **Back-eye needle**: Yes
- **Needle rotation**: Yes
- **Bevel direction**: Upward
- **First needle**: Arterial

**Missing data**
Direction of Arterial Needle

- **Retrograde**: 37%
- **Antegrade**: 63%

FME © Copyright MTP - Does cannulation technique impact...
Needle Size

- 15 G: 61.5%
- 16 G: 33.3%
- 17 G: 1.7%
- Others: 1.0%
- 14 G: 2.4%
Nurses’ Experience in Dialysis

- > 5 yrs: 66%
- > 2-5 yrs: 19%
- > 1-2 yrs: 7%
- > 6-12 mos: 4%
- > 6-12 mos: 4%
## Preliminary results

### Logistic regression on the odds ratio to reach Kt/V > 1.2

<table>
<thead>
<tr>
<th></th>
<th>Odds ratio</th>
<th>95% confidence interval</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (male vs. female)</td>
<td>0.293</td>
<td>0.243 - 0.354</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Post-dialytic body weight (per kg)</td>
<td>0.938</td>
<td>0.933 - 0.944</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Treatment time (per min)</td>
<td>1.036</td>
<td>1.032 - 1.041</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Treatment modality (on-line HDF vs. HD)</td>
<td>1.886</td>
<td>1.603 - 2.219</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Direction of arterial needle (retrograde vs. antegrade)</td>
<td>1.275</td>
<td>1.088 - 1.494</td>
<td>0.003</td>
</tr>
<tr>
<td>Needle size (vs. 17 G)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>16 G</td>
<td>2.962</td>
<td>1.786 – 4.913</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>15 G</td>
<td>6.626</td>
<td>3.963 – 11.079</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>14 G</td>
<td>12.145</td>
<td>6.016 – 24.520</td>
<td>&lt;0.001</td>
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<td>Fistula type (graft vs. native arterio-venous fistula)</td>
<td>1.930</td>
<td>1.446 – 2.576</td>
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<td>Blood flow (vs. &lt; 300 ml/min)</td>
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<td></td>
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<tr>
<td>300 – 350</td>
<td>2.172</td>
<td>1.755 – 2.687</td>
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<tr>
<td>350 – 400</td>
<td>2.651</td>
<td>2.103 – 3.343</td>
<td>&lt;0.001</td>
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<tr>
<td>&gt;400</td>
<td>3.156</td>
<td>2.274 – 4.380</td>
<td>&lt;0.001</td>
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<tr>
<td>Dialyser surface (vs. 1.30 – 1.50 m²)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1.51 – 1.80</td>
<td>1.582</td>
<td>1.279 – 1.957</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>&gt;1.80</td>
<td>1.578</td>
<td>1.222 – 2.037</td>
<td>&lt;0.001</td>
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</table>
Summary

- Vascular access management and cannulation are important issues in haemodialysis care.
- Some variability in cannulation practices exists between countries and centres.
- Observations of this survey provide a broad basis to further study the relationship between vascular access practices and patient outcomes.
- The first preliminary analysis already indicates that there is a relationship between vascular access cannulation practices and the probability of reaching an adequate dialysis dose.
Techniques for AVF cannulation are known to vary from clinic to clinic, mainly because of historical training approaches in the individual settings.

Unfortunately the influence of cannulation technique on fistula survival has never been an objective of clinical research.

There are several questions never answered:
- Which needle Gauge?
- Puncture technique: which one is the best?
- Bevel up or down?
- Retrograde or antegrade arterial needle puncture?
The aim of the study was to investigate the impact of needle gauge, cannulation technique, bevel direction, retrograde or antegrade arterial needle direction, blood flow and venous pressure on the survival of the vascular access.
Cannulation technique vs VA survival: Patients and Methods

Based on the April 2009 survey conducted in 171 dialysis units located in Europe, Middle East and Africa, a cohort of patients was selected for follow-up to investigate vascular access survival.
Cannulation technique vs VA survival: Statistical Analysis

• Primary outcome in our analysis was the **time of the first surgical access intervention** resulting in the creation of a new access, where survey date serves as baseline.

• **The observation period was 3 years** (from April 2009 till March 2012).

• To adjust for individual patient differences, the following information was extracted from the clinical database: **Patient age and gender, BMI, prevalence of diabetes and the use of ACE inhibitors, platelet anti-aggregants, salicylic acid and anticoagulants**. Additionally the median blood flow prescriptions was documented at centre level at the time of the survey.
Cannulation technique vs VA survival: Results #1

• Out of the 10,807 patients enrolled for the original survey, access survival data was available for 7,058 (65%) from Portugal, UK, Italy, Turkey, Romania, Slovenia, Poland and Spain.

• Mean age was 63.5±15.0 years; 38.5% were female; 27.1% were diabetics; 90.6% had a native fistula and 9.4% had a graft. Access location was distal for 51.2% of patients. During the follow-up, 51.1% were treated with anti-aggregants and 2.8% with anti-coagulant.
Cannulation technique vs VA survival: Results #2

- Prevalent needle sizes were 15 G and 16 G for 63.7% and 32.2% of the patients, respectively (14 G: 2.7%, 17 G: 1.4%).
- Cannulation technique was area for 65.8%, rope-ladder for 28.2% and buttonhole for 6% of patients, and the direction of arterial puncture was antegrade for 57.3%. The bevel direction was upward for 70.2% of the patients. The prevalent combination between arterial needle puncturing and bevel direction was antegrade with bevel upward (43.1%) followed by retrograde with bevel downward (27.1%). The proportion of the two other combination, antegrade and retrograde with bevel downward were 14.2% and 15.6% respectively.
- Median blood flow was 350-400 mL/min.
Needle size, blood flows and venous pressure levels

Parisotto MT et al. (2014). Cannulation technique influences arteriovenous fistula and graft survival.
Kidney Int doi: 10.1038/ki.2014.96
KM vascular access survival according to VP


![Vascular Access cumulative survival probability graph](image)
Cox model with primary outcome vascular survival


<table>
<thead>
<tr>
<th>Parameter</th>
<th>Category</th>
<th>Reference</th>
<th>HR</th>
<th>95% CI</th>
<th>P-value</th>
<th>Marginal P-value</th>
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<td>0.89</td>
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<td>Female</td>
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<td>1.00</td>
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<td>0.06</td>
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<td>No</td>
<td>1.39</td>
<td>1.12</td>
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<td>Vintage</td>
<td>6-24 Months</td>
<td>0-6 Months</td>
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<td>Fistula type</td>
<td>Graft</td>
<td>Fistula</td>
<td>1.74</td>
<td>1.48</td>
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<td>AV-fistula location</td>
<td>Right</td>
<td>Left</td>
<td>1.13</td>
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<td>1.49</td>
<td>1.33</td>
<td>1.67</td>
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<td>Needle size</td>
<td>14G</td>
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<td>1.25</td>
<td>0.85</td>
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<td>16G</td>
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<td></td>
<td>17G</td>
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<td>1.42</td>
<td>0.93</td>
<td>2.17</td>
<td>0.11</td>
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</table>

Abbreviations: CI, confidence interval; HR, hazard ratio.
Cox model with primary outcome vascular survival


<table>
<thead>
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<th>P-value</th>
<th>Marginal P-value</th>
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<tr>
<td>Cannulation technique</td>
<td>Buttonhole</td>
<td>Area</td>
<td>0.78</td>
<td>0.61</td>
<td>1.00</td>
<td>0.05</td>
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<td></td>
<td>Rope-ladder</td>
<td></td>
<td>0.89</td>
<td>0.79</td>
<td>1.00</td>
<td>0.06</td>
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<td>Bevel and needle direction</td>
<td>Antegrade + bevel down</td>
<td>Antegrade + bevel down</td>
<td>0.97</td>
<td>0.82</td>
<td>1.14</td>
<td>0.71</td>
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<td>Retrograde + bevel up</td>
<td>Retrograde + bevel up</td>
<td>0.93</td>
<td>0.81</td>
<td>1.07</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td>Retrograde + bevel down</td>
<td>Retrograde + bevel down</td>
<td>1.18</td>
<td>1.01</td>
<td>1.37</td>
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<tr>
<td>Blood flow</td>
<td>&lt;300 ml/min</td>
<td>300-350 ml/min</td>
<td>1.18</td>
<td>1.01</td>
<td>1.36</td>
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<td>350-400 ml/min</td>
<td>350-400 ml/min</td>
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<td>0.80</td>
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<td>0.16</td>
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<td>&gt;400 ml/min</td>
<td>&gt;400 ml/min</td>
<td>0.93</td>
<td>0.75</td>
<td>1.15</td>
<td>0.49</td>
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<td>Venous pressure</td>
<td>&lt;100 mm Hg</td>
<td>100-150 mm Hg</td>
<td>1.51</td>
<td>1.11</td>
<td>2.07</td>
<td>0.009</td>
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<td></td>
<td>150-200 mm Hg</td>
<td>150-200 mm Hg</td>
<td>1.40</td>
<td>1.20</td>
<td>1.64</td>
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<td>200-300 mm Hg</td>
<td>200-300 mm Hg</td>
<td>1.87</td>
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<td>2.26</td>
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<tr>
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<td>&gt;300 mm Hg</td>
<td>&gt;300 mm Hg</td>
<td>2.09</td>
<td>1.21</td>
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<td>Arm compression at the time of cannulation</td>
<td>None</td>
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<td>1.25</td>
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<td>1.49</td>
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<td>Tourniquet</td>
<td>Tourniquet</td>
<td>1.30</td>
<td>1.07</td>
<td>1.58</td>
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</tbody>
</table>

Abbreviations: CI, confidence interval; HR, hazard ratio.
Cannulation technique vs VA survival: Summary

In summary, the study revealed that area cannulation technique, despite being the most commonly used, was inferior to both rope-ladder and buttonhole for the maintenance of Vascular Access functionality.

With regard to the effect of needle and bevel direction, the combination of antegrade position of arterial needle with bevel up or down was significantly associated with better access survival than retrograde positioning with bevel down.
Cannulation technique vs VA survival: Summary

Results referring to the type and location of access and the technical parameters (i.e. venous pressure) were as follows:

There was an increased risk of access failure for graft versus fistula, proximal vs distal location, right arm vs left arm, and the presence of a venous pressure greater than 150 mmHg.

The results on venous pressure are worth considering. A venous pressure of 200-250 mmHg is considered acceptable by the scientific community; the results of this study put these values under discussion. However, further investigations are required to clarify the topic fully.
Discussion: Needle Gauge & Blood Flow – the Chicken or Egg dilemma

• In our study, 17-gauge needle was associated with increased risk of early fistula termination. The same applies for blood flows below 300 mml/min.

• The question: Is it the smaller needle influencing the fistula survival or the use of smaller needles indicates an already existing fistula malfunction? Is it the low blood flow affecting the fistula survival or an already problematic fistula allows only the use of low blood flow?

Future investigation are needed to fully clarify these results.
More info
Effect of arterial needle rotation and the onset of complications

Using as a test of significance the chi-square (P = 0.0009), there was evidence that there is a strong association between the rotation of the needle and the probability, increased by 40% (odds ratio 1.4), to develop complications during cannulation.

<table>
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<tr>
<th>Data analyzed</th>
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<th>Yes Complication</th>
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<tr>
<td>Needle Rotation No</td>
<td>5691</td>
<td>170</td>
<td>5861</td>
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<tr>
<td>Needle Rotation Yes</td>
<td>4390</td>
<td>187</td>
<td>4577</td>
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<td>Total</td>
<td>10081</td>
<td>357</td>
<td>10438</td>
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Chi-square

<table>
<thead>
<tr>
<th>Strength of association</th>
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<tr>
<td>Relative Risk</td>
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<tr>
<td>95% confidence interval</td>
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<tr>
<td>Odds ratio</td>
</tr>
<tr>
<td>95% confidence interval</td>
</tr>
</tbody>
</table>
Effect of bevel direction in the arterial needle position (antegrade/retrograde)

Bevel Up

Antegrade Puncture

Bevel Down

Retrograde Puncture

Bionic Medizintechnick GmbH
Effect of bevel direction in the Graft - PTFE (intraluminal)

Bevel up

Blood flow direction

Bevel down

Intraluminal photography

left Bevel up
right Bevel down

Quelle: Langkau G, Spektrum Nephrologie 1997; 10:3-14
NeproCare 10-01-26

© copyright Bionic Medizintechnik GmbH
Needle diameter vs blood flow and flow pattern vector

Needle diameter = 1,5 mm (17G)

\[ V_{\text{max}} = 6,28 \text{ m/s} \]

\[ Q_B = 250 \text{ ml/min} \]

\[ V_{\text{max}} = 8,79 \text{ m/s} \]

\[ Q_B = 350 \text{ ml/min} \]

Needle diameter = 1,8 mm (15G)

\[ V_{\text{max}} = 4,14 \text{ m/s} \]

\[ Q_B = 250 \text{ ml/min} \]

\[ V_{\text{max}} = 5,80 \text{ m/s} \]

\[ Q_B = 350 \text{ ml/min} \]
Arterial needle direction

Antegrade: with the flow

Retrograde: against the flow

Both needles antegrade:
1. Easier for nurse to puncture
2. Easier for self-puncturing
3. May be fistula protective
Antegrade puncturing may be fistula protective

- Increased risk of haematoma formation from retrograde filling
- Tract closure through flow force by antegrade puncture

From: Woodson & Shapiro: D&T: Feb/Mar. 1974, 29-30
Summary and Conclusions

1. Rope-ladder cannulation technique as preferred option and only when there is a limited area for cannulation sites, or for the potential self-care dialysis patients choose buttonhole
2. Arterial needle insertion in the antegrade direction (blood flow direction) and with bevel downward
3. In the case of arterial needle retrograde position, the direction of the bevel should be upward
4. 15 G needles are recommended
5. Blood flow \( \geq 350 \text{ ml/m} \)
6. Venous pressure around 150 mmHg
7. Correct haemostasis
8. Patients education to care for the VA
Caring together

Vascular Access Cannulation and Care
A Nursing Best Practice Guide for Arteriovenous Fistula

Joint project of Fresenius Medical Care and EDTNA/ERCA to achieve enhanced multidisciplinary renal team practice in dialysis and develop a Vascular Access Best Practice Guide
Caring together

Project Objectives

- Raise awareness of the importance for vascular access management as the “patient’s lifeline”
- Define vascular access cannulation practices based on clinical evidence to minimize complications
- Develop a best practice guide for vascular access cannulation and care
Caring together

Project Coordinators

Jitka Pancírová  
(on behalf of EDTNA/ERCA)

Maria Teresa Parisotto  
(on behalf of Fresenius Medical Care)
Caring together

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Iris Romash
Joao Fazendeiro
Maria Teresa Parisotto
Project Timeline

- **Sep 2010**: Project launch in Dublin and pre-project Survey
- **Sep 2011**: Presentation of survey results in Ljubljana
- **Jan/Dec 2012**: Project framework definition, preparation of the observational study protocol, selection of participating countries and centres
- **Jan/Dec 2013**: Data Collection and data analysis
- **Apr 2013**: Kick-off meeting in Bad Homburg – Germany
- **Apr’13/Aug’14**: Development of the VA Best Practice Guide
Project Kick Off Meeting
April 18-19th, 2013, Bad Homburg, Germany
The tasks of the authors

• As “Subject Matter Expert” define what should be in the Best Practice Guide (in scope, out of scope)
• Define each topic content
• Create a comprehensive draft
• Make sure what is written in the draft is correct
• Do research to gather data per each topic
• Use additional literature to confirm or change the original statements
What should be covered by the Vascular Access Guide?

In Scope

Responsibilities of the nurse
Assessment of the AVF
Hygiene and infection control
Cannulation techniques

Needle removal and haemostasis
Complications: prevention and detection
Documentation and reporting
Patient education
What should be covered by the Vascular Access Guide?

Out of Scope

Arteriovenous Grafts (AVG)
Central Venous Catheters (CVC)

Patient self-cannulation
Preparation for surgery and immediate post-operative care
Best Practice Guide outline #1

1. Preface
2. Executive summary
3. Introduction
4. Background
5. VA for haemodialysis
6. Arteriovenous Fistula
7. Hygiene and infection control
8. Arteriovenous Fistula cannulation
9. Complications of Arteriovenous Fistula (related to the fistula)
10. Arteriovenous Fistula monitoring and evaluation
11. Reporting of Arteriovenous Fistula incidents
12. Patient education for the care of Arteriovenous Fistula
13. From Empiric Evaluation to clinical research evidence
14. Conclusions
15. Appendix
16. Index
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- **Sep 2010**: Project launch in Dublin and pre-project Survey
- **Jan/Dec 2012**: Presentation of survey results in Ljubljana
- **Jan/Dec 2013**: Project framework definition, preparation of observational study protocol, selection of participating countries and centres
- **Apr 2013**: Data Collection and data analysis
- **Apr′13/Aug′14**: Kick-off meeting in Bad Homburg – Germany
- **Sep 2014**: Development of the VA Best Practice Guide
- **Sep 2014**: Launch of the VA Best Practice Guide: EDTNA/ERCA 2014
Caring together

Vascular Access Guide: The launch!
Caring together

Vascular Access Guide

Reading examples

<table>
<thead>
<tr>
<th>Action</th>
<th>Possible signs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Look – inspection (see Figure 10)</td>
<td>Oedema, redness, swelling, bruising, haematoma, rash or break in skin, bleeding, other exudate, aneurysm or pseudo-aneurysm</td>
</tr>
<tr>
<td>Feel – palpation (see Figure 11)</td>
<td>Character of pulse, change in temperature, atypical warmth, tenderness Direction of the flow, flow characteristics along the fistula (thrill versus pulse) N.B. The thrill should feel like a continuous vibration, not a strong pulsation</td>
</tr>
<tr>
<td>Listen to the fistula – auscultation (see Figure 12)</td>
<td>Auscultation for bruit along the vein for the quality of the sound and its amplitude N.B. The bruit – a whooshing sound – should be strong and continuous; each sound linked to the one before</td>
</tr>
</tbody>
</table>

In case of absence of bruit and/or thrill, DO NOT cannulate the AVF!
Dos and Don’ts for removing scabs

Dos
- Use sterile tweezers/scab picker to remove scabs
- Soak two gauzes/swabs with saline or alcohol-based solution
- Stretch the skin around the scab in opposite directions

Don’ts
- Remove the scab with the needle that will be used for cannulation – this contaminates the needle
- Use a needle to remove the scab; patient’s skin can be injured
- Let patients remove their own scabs
- Cannulate unless the scabs are completely removed
- Use the buttonhole track if bleeding occurs when removing the scabs (use a sharp needle to access the AVF at a new site for this treatment)

Highlighted boxes
Vascular Access Guide

Reading examples

- Tape the needle in place
  * Tape the needle at an angle similar to that of insertion
  * To avoid the needle tip from moving DO NOT press the needle shaft flat against the skin as this can cause damage to the intima of the vessel
  * Secure the needle using a minimum of three strips of tape: one to fix the wings, a second on top of it to secure the needle and a third one to secure the needle tubing (see Figure 18)
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Thank you for your attention!