



Contents lists available at ScienceDirect

## Clinical Nutrition

journal homepage: <http://www.elsevier.com/locate/clnu>

## ESPEN Guideline

## ESPEN guideline on home parenteral nutrition

Loris Pironi <sup>a,\*</sup>, Kurt Boeykens <sup>b</sup>, Federico Bozzetti <sup>c</sup>, Francisca Joly <sup>d</sup>, Stanislaw Klek <sup>e</sup>, Simon Lal <sup>f</sup>, Marek Lichota <sup>g</sup>, Stefan Mühlebach <sup>h</sup>, Andre Van Gossum <sup>i</sup>, Geert Wanten <sup>j</sup>, Carolyn Wheatley <sup>k</sup>, Stephan C. Bischoff <sup>l</sup>

<sup>a</sup> Center for Chronic Intestinal Failure, St. Orsola-Malpighi University Hospital, Bologna, Italy

<sup>b</sup> AZ Nikolaas Hospital, Nutrition Support Team, Sint-Niklaas, Belgium

<sup>c</sup> Faculty of Medicine, University of Milan, Italy

<sup>d</sup> Beaujon Hospital, APHP, Clichy, University of Paris VII, France

<sup>e</sup> Stanley Dudrick's Memorial Hospital, Skawina, Poland

<sup>f</sup> Salford Royal NHS Foundation Trust, Salford, United Kingdom

<sup>g</sup> Intestinal Failure Patients Association "Appetite for Life", Cracow, Poland

<sup>h</sup> Division of Clinical Pharmacy and Epidemiology and Hospital Pharmacy, University of Basel, Basel, Switzerland

<sup>i</sup> Hôpital Erasme and Institut Bordet, Brussels, Belgium

<sup>j</sup> Intestinal Failure Unit, Radboud University Medical Centre, Nijmegen, the Netherlands

<sup>k</sup> Support and Advocacy Group for People on Home Artificial Nutrition (PINNT), United Kingdom

<sup>l</sup> University of Hohenheim, Institute of Nutritional Medicine, Stuttgart, Germany

## ARTICLE INFO

## Article history:

Received 2 March 2020

Accepted 6 March 2020

## Keywords:

Central venous access device

Home parenteral nutrition

Intestinal failure

Multidisciplinary team

Parenteral nutrition admixture

Patient training

## SUMMARY

This guideline will inform physicians, nurses, dietitians, pharmacists, caregivers and other home parenteral nutrition (HPN) providers, as well as healthcare administrators and policy makers, about appropriate and safe HPN provision. This guideline will also inform patients requiring HPN. The guideline is based on previous published guidelines and provides an update of current evidence and expert opinion; it consists of 71 recommendations that address the indications for HPN, central venous access device (CVAD) and infusion pump, infusion line and CVAD site care, nutritional admixtures, program monitoring and management. Meta-analyses, systematic reviews and single clinical trials based on clinical questions were searched according to the PICO format. The evidence was evaluated and used to develop clinical recommendations implementing Scottish Intercollegiate Guidelines Network methodology. The guideline was commissioned and financially supported by ESPEN and members of the guideline group were selected by ESPEN.

© 2020 Elsevier Ltd and European Society for Clinical Nutrition and Metabolism. All rights reserved.

## 1. Introduction

Parenteral nutrition (PN) is a type of medical nutrition therapy provided through the intravenous administration of nutrients such as amino acids, glucose, lipids, electrolytes, vitamins and trace elements [1]. It is categorized as total (or exclusive) PN, where it

meets the patient's nutritional needs in entirety, and as supplemental (partial or complementary) PN, where nutrition is also provided via the oral or enteral route [1]. PN can be administered either in, or outside, the hospital setting; the latter defined as home parenteral nutrition (HPN) [1].

HPN is the primary life-saving therapy for patients with chronic intestinal failure (CIF) due to either benign (absence of malignant disease) or malignant diseases [2–4]. HPN may also be provided as palliative nutrition to patients in late phases of end-stage diseases [1]. As HPN is sometimes used to prevent or treat malnutrition in patients with a functioning intestine, who decline medical nutrition via the oral/enteral route, HPN and CIF cannot be considered synonymous [2]. Thus, on the basis of underlying gastrointestinal function and disease, in tandem with patient characteristics, four clinical scenarios for the use of HPN can be

*Abbreviations:* AIO, all-in-one parenteral nutrition admixture; CDC, Centers for Disease Control and Prevention; CIF, chronic intestinal failure; CRBSI, catheter-related bloodstream infection; CVAD, central venous access device; CVC, central venous catheter; EN, enteral nutrition; HPN, home parenteral nutrition; IF, intestinal failure; NST, nutrition support team; PICC, peripherally inserted central venous catheter; PN, parenteral nutrition; QoL, quality of life; RCT, randomized controlled trial.

\* Corresponding author.

E-mail address: [loris.pironi@unibo.it](mailto:loris.pironi@unibo.it) (L. Pironi).

<https://doi.org/10.1016/j.clnu.2020.03.005>

0261-5614/© 2020 Elsevier Ltd and European Society for Clinical Nutrition and Metabolism. All rights reserved.

identified [2–4]: HPN as primary life-saving therapy for a patient with CIF due to benign disease; HPN for CIF due to malignant diseases, often transiently occurring during curative treatments; HPN included in a program of palliative care for incurable malignant disease, to avoid death from malnutrition; HPN used to prevent or treat malnutrition in patients with a functioning intestine, who decline other types of medical nutrition ('no-CIF scenario'). The goal and characteristics of the HPN program, as well as the specific needs of the patient, may differ among the four clinical scenarios (Table 1).

The first European Society for Clinical Nutrition and Metabolism (ESPEN) guideline on HPN was published in 2009 [3]. It consisted of 26 recommendations, 10 were based on some evidence (grade B recommendations) but 16 were mostly based on expert opinion ('grade C recommendations') [3]. In 2016, ESPEN guidelines for CIF due to benign disease was published, including 11 recommendations on HPN management, 17 on PN formulation and 22 on the prevention and treatment of central venous catheter (CVC)-related complications [4]. The grade of evidence was very low for 31 recommendations, low for 14, moderate for 3 and high for 2, whereas the strength of the recommendations was weak for 18 and strong for 32 [4]. Most of the recommendations from both guidelines are still valid, particularly those covering nutritional requirements, metabolic complications and central venous access device (CVAD) management. Other guidelines and standards for HPN have also been provided by scientific societies and government bodies [5–15]; however, a systematic review revealed substantial differences among the recommendations published [10]. Furthermore, the management and provision of HPN differs among countries and among HPN centers within countries [16,17], although HPN provision by different programs should be homogeneous in order to ensure equity of patient access to an appropriate and safe HPN service.

Thus, an updated version of ESPEN guidelines on HPN care was commissioned in order to incorporate new evidence since the publication of the previous ESPEN guidelines, as well as to highlight recommendations on safe HPN administration and also to include the patient's perspective.

### 1.1. Aim

The aim of the present guideline is to provide recommendations for the appropriate and safe provision of HPN. This guideline does not include recommendations for the patient's nutrient requirements in specific conditions, for which the reader can refer to previous ESPEN guidelines [3,4,15].

## 2. Methods

The present guideline was developed according to the standard operating procedure for ESPEN guidelines [18]. It is an update of previous guidelines [3–15]. The guideline was developed by an expert group from seven European countries, representing different professions including eight physicians (LP, FB, FJ, SK, SL, AVG, GW, SCB), a pharmacist (SM), a nurse (KB) and two patient representatives (ML, CW).

### 2.1. Methodology of guideline development

Based on the standard operating procedures for ESPEN guidelines and consensus papers, the first step of the guideline development was the formulation of so-called PICO questions, which address specific patient groups or problems, interventions, compares different therapies and are outcome-related [18]. In total, 17 PICO questions were created and were split into six main chapters, "indications for HPN", "CVAD and infusion pump", "infusion line and CVAD site care", "nutritional admixtures", "program monitoring" and "management".

The PICO questions for the different topics were allocated to subgroups/experts who reviewed the previous guidelines and standards [3–15] and performed a literature search to identify suitable meta-analyses, systematic reviews and primary studies (for details see "search strategy" below). A total of 71 recommendations were formulated to answer the PICO questions. The grading system of the Scottish Intercollegiate Guidelines Network (SIGN) was used to grade the literature [19]. Allocation of studies to the different levels of evidence is shown in Table 2. The working group

**Table 1**  
Aims of the HPN program, intravenous supplementation and patient care requirements, categorized according to the clinical scenarios based on the underlying clinical condition.

HPN program and patient care requirement	Benign CIF scenario	Malignant scenarios	No CIF scenario
<b>Aim (additional to avoiding death from malnutrition)</b>	Social, employment & familial rehabilitation; improved quality of life; intestinal rehabilitation	<ul style="list-style-type: none"> <li>• Treatment of CIF due to ongoing oncological therapy or to gastrointestinal obstruction</li> <li>• Palliative care</li> </ul>	Alternative to other potentially effective modalities of nutritional support (e.g. enteral) refused by the patient.
<b>Expected duration</b>	Temporary or permanent (life-long)	Mostly temporary: <ul style="list-style-type: none"> <li>• Short &lt;6 months</li> <li>• Long: &gt;6 months</li> </ul>	Temporary or permanent
<b>Intravenous supplementation requirements</b>	Supplemental or total; high fluid volume and electrolyte contents often required	CIF: mostly supplemental, but can be total; mostly normal volume (high volume may be required in GI obstruction) Palliative: mostly total; normal/low volume	Mostly supplemental with normal volume
<b>Type of PN admixture more frequently required</b>	"Tailored" or "customized" (compounded), requiring refrigeration	"Premade" or "premixed" (ready-to-use)	"Premade" or "premixed" (ready-to-use)
<b>Patient mobility and dependency on caregiver</b>	Mostly ambulatory and independent (depending on age and co-morbidity). Travelling for work and holidays often required	CIF: ambulatory or housebound, mostly dependent Palliative: housebound, from bed to chair, dependent	Ambulatory, or housebound (neurological disorders), sometimes dependent
<b>Patient homecare nurse assistance requirement</b>	Rare; depending on age and co-morbidity	Frequent	Sometimes

CIF, chronic intestinal failure; HPN, home parenteral nutrition; PN, parenteral nutrition.

**Table 2**  
Levels of evidence.

1++	High quality meta-analyses, systematic reviews of RCTs, or RCTs with a very low risk of bias
1+	Well-conducted meta-analyses, systematic reviews, or RCTs with a low risk of bias
1-	Meta-analyses, systematic reviews, or RCTs with a high risk of bias
2++	High quality systematic reviews of case control or cohort studies. High quality case control or cohort studies with a very low risk of confounding or bias and a high probability that the relationship is causal
2+	Well-conducted case control or cohort studies with a low risk of confounding or bias and a moderate probability that the relationship is causal
2-	Case control or cohort studies with a high risk of confounding or bias and a significant risk that the relationship is not causal
3	Non-analytic studies, e.g. case reports, case series
4	Expert opinion

According to the Scottish Intercollegiate Guidelines Network (SIGN) grading system. Source: SIGN 50: A guideline developer's handbook. Quick reference guide October 2014 [19].

added commentaries to the recommendations detailing the basis of the recommendations made.

Recommendations were graded according to the levels of evidence available [20] (see Table 3). In some cases, a downgrading was necessary, for example, due to the lack of quality of primary studies included in a meta-analysis. The wording of the recommendations reflects the grades of recommendations; level A is indicated by “shall”, level B by “should” and level O by “can/may”. A good practice point (GPP) is based on experts' opinions due to the lack of studies; in this situation, the choice of wording was not restricted.

Between February 21st and March 25th 2019, online voting on the recommendations was undertaken using the “guideline-services.com” platform. All ESPEN members were invited to agree or disagree with, and to comment upon, each of the original 72 recommendations and 7 statements generated by the guideline committee. A first draft of the guidelines was also made available to participants at the same time. 61 recommendations and 5 statements reached an agreement of >90%, 10 recommendations reached an agreement of >75–90% and 2 statements reached an agreement of ≤75%. Those recommendations/statements with an agreement >90% (i.e. those with a strong consensus) were directly passed, while all others were revised according to the comments made and then voted on again during a consensus conference which took place in Frankfurt on April 29th 2019. Apart from one, all recommendations received an agreement of >90%. Two former statements were transformed into recommendations, both with >90% agreement. Three of the original recommendations were deleted. Thus, the final guidelines comprise of 71 recommendations and 5 statements (Table 4). To support the recommendations, the ESPEN guideline office created evidence tables of relevant meta-analyses, systematic reviews and (R)CTs, all of which are available online as supplemental material to these guidelines.

## 2.2. Search strategy

The literature search was performed separately for each PICO question in March 2018. Pubmed, Embase and Cochrane databases were searched using the filters “human”, “adult” and “English”. Table 5 shows the search terms used for the PICO questions. The

results were pre-screened based on the abstracts of articles. In addition to the above databases, websites from nutritional (nursing) societies in English speaking or bilingual countries including the English language were searched for practice guidelines.

### 1. Indications for HPN

#### 1. What are the indications for HPN?

##### Recommendation 1

**HPN should be administered to those patients unable to meet their nutritional requirements via the oral and/or enteral route and who can be safely managed outside of the hospital.**

Grade of Recommendation: GPP – Strong consensus (95.8% agreement)

##### Commentary

Several guidelines and standards on HPN have been published [3–15]. PN is a life-saving therapy to those unable to meet their nutritional requirements by oral/enteral intake. Clearly, no randomized controlled trial (RCT) can be conducted to compare HPN with placebo to confirm the life-saving efficacy of HPN therapy in this condition [3]. Furthermore, no absolute contraindications exist to the use of PN. However, the presence of organ failures and metabolic diseases, such as heart failure, renal failure, type 1 diabetes, may be associated with reduced tolerance to PN and may require careful and specific adaptations of the HPN program to meet the patient's specific clinical needs.

Six guidelines and one expert opinion-based standard on HPN in this setting were compared in a systematic review [10]. Although the guidelines generally covered the same topics, substantial differences were observed among the recommendations. Most did not provide information on intravenous medication, metabolic bone disease and indications in patients with malignant disease. Moreover, grading discrepancies among various guidelines were found, as identical recommendations were often labeled with different grades. Thus, the present guideline updates the recommendations from previous guidelines and standards relating to the appropriateness and safety of HPN. Nutritional requirements in specific clinical conditions, as well as the diagnosis and treatment of CVAD and metabolic complications are not addressed in the present guideline. Recommendations in previous ESPEN guidelines about the latter topics are still valid [3,4].

**Table 3**  
Grades of recommendation [18].

A	At least one meta-analysis, systematic review, or RCT rated as 1++, and directly applicable to the target population; or A body of evidence consisting principally of studies rated as 1+, directly applicable to the target population, and demonstrating overall consistency of results
B	A body of evidence including studies rated as 2++, directly applicable to the target population; or A body of evidence including studies rated as 2+, directly applicable to the target population and demonstrating overall consistency of results; or and demonstrating overall consistency of results; or Extrapolated evidence from studies rated as 1++ or 1+
O	Evidence level 3 or 4; or Extrapolated evidence from studies rated as 2++ or 2+
GPP	Good practice points/expert consensus: Recommended best practice based on the clinical experience of the guideline development group

**Table 4**

Classification of the strength of consensus, according to the AWMF [20] methodology and results of the online and consensus conference voting.

		Online Voting	Consensus Conference
<b>Strong consensus</b>	Agreement of >90% of participants	61 R + 5 S	10 R
<b>Consensus</b>	Agreement of >75–90% of participants	10 R	1 R
<b>Majority agreement</b>	Agreement of >50–75% of participants	2 S <sup>a</sup>	–
<b>No consensus</b>	Agreement of <50% of participants	–	–
<b>Deleted</b>		–	3 R <sup>b</sup>

R = Recommendation; S = Statement.

<sup>a</sup> These two statements were converted into recommendations.<sup>b</sup> Two recommendations were deleted during the revision after the online voting, one recommendation was deleted during the consensus conference.**Table 5**

Search strategy.

PICO question	Search terms used in combination with “home parenteral nutrition”, “human” and “adult”
1. What are the indications for HPN?	“guidelines”
2. What are the criteria for an effective HPN program?	“registries”
3. What are the criteria for a safe HPN program?	“indications” “malignant” OR “cancer”, “program” “organization and administration OR management” “multidisciplinary” AND “team”
4. Which venous access device should be chosen?	“central venous catheter” OR “central venous access device”
5. Which infusion control devices should be used for HPN?	“peripherally AND inserted AND central AND catheters” “infusion pumps”
6. Which should be the appropriate infusion line management?	“central venous catheter related infection” “catheter-associated infection OR contamination OR sepsis OR complications OR occlusion” “catheter dressing OR ointment OR lock” “catheter hub” “skin antisepsis” “aseptic technique” “catheter exit site” “hand decontamination” “swimming OR bathing OR showering” “sutureless device” “catheter securement” “administration set OR intravenous tubing” “gloves” “needleless connector OR device” “antiseptic barrier cap” “port needle” “pre-filled syringes” “taurolidine” “admixture”
7. Which nutritional admixture bag should be chosen?	“premade OR premixed OR multichambered OR ready to use OR “all in one”
8. What are the critical steps during the preparation of PN admixtures?	“compounded OR customized”
9. How should PN admixture be delivered?	“stability”
10. What should be the HPN admixture time and rate of infusion?	“delivery” “infusion” “rate” “blood glucose” “glycaemia”
11. How should patients on HPN be monitored?	“monitoring” “follow-up” “tolerance” “complications” “quality of care” “intestinal failure”
12. Which are the local and personnel preconditions for HPN ?	“central venous catheter complications”
13. Which are the requirements for the hospital centers that care for HPN patients?	“program”
14. Which are the requirements for the nutritional support team?	“organization and administration OR management”
15. How should emergencies be managed?	“multidisciplinary AND team”
16. How should travelling with HPN be organized?	“emergency” “admission” “central venous catheters complications”
17. Which criteria should be used to monitor the safety of HPN program provision?	“travel OR travelling” “quality of health care” “quality of care”

2. What are the criteria for effective HPN program ?

### Recommendation 2

**HPN should be prescribed as the primary and life-saving therapy for patients with transient-reversible or permanent-irreversible CIF due to non-malignant disease**

**Grade of Recommendation B – Strong consensus (94.7% agreement)**

#### Commentary

CIF has been defined as a chronic “reduction of gut function below the minimum necessary for the absorption of macronutrients and/or water and electrolytes, such that intravenous supplementation is required to maintain health and/or growth”, in metabolically stable patients [2]. CIF can be due to either benign or malignant disease and may be reversible or irreversible [2].

The underlying diseases and the mechanisms of CIF due to benign disease in adults have been described in a recent international ESPEN survey [21]. Crohn's disease, mesenteric ischemia, surgical complications, chronic intestinal pseudo-obstruction and radiation enteritis were the main underlying diseases, accounting for around 75% of cases. Short bowel syndrome was the main mechanism (around two-thirds of cases), while the remaining 33% of cases were due to intestinal dysmotility, enterocutaneous fistulas, intestinal mechanical obstruction and extensive mucosal diseases [21].

HPN is the primary and life-saving therapy for CIF [4]. The outcome of patients on HPN for CIF due to benign disease has been reported in many single and multicenter retrospective studies [22–28] and by an ESPEN prospective five year follow up [29–31]. These studies demonstrated that: weaning from HPN after one to two years of starting may occur in 20%–50% of patients; the five year survival probability on HPN ranges from 70 to 80% depending on the underlying disease; CIF may be associated with life-threatening complications of either the underlying disease or HPN, the latter accounting for around 14% of total deaths (such as CVAD-related complications and intestinal failure associated liver disease); the outcome of patients in terms of reversibility, treatment-related morbidity and mortality, and survival probability is strongly dependent on care and support from an expert multidisciplinary nutrition support team (NST).

In Europe, the prevalence of HPN for CIF due to benign disease has been estimated to range from five to 20 cases per million population [22], with the exception of Denmark, where 80 cases per million have been recently reported [26].

### Recommendation 3

**HPN can be considered for patients with CIF due to malignant disease**

**Grade of Recommendation 0 – Strong consensus (95.8% agreement)**

#### Recommendation 4

**HPN should be prescribed to prevent an earlier death from malnutrition in advanced cancer patients with CIF, if their life expectancy related to the cancer is expected to be longer than one to three months, even in those not undergoing active oncological treatment.**

**Grade of Recommendation B - Consensus (90% agreement)**

#### Commentary

A mean survival of around 48 days has been reported in patients with malignant obstruction receiving palliative care without artificial nutritional support [32]. International guidelines [15,33–35] generally advocate the use of PN in patients with malignancy who have failed oral and enteral nutrition (EN) and who have an expected survival longer than one to three months, which is the longest predictable survival in an individual unable to maintain adequate oral nutrition without artificial nutritional support.

A meta-analysis by Naghibi et al. [36] reported that 45% of incurable cancer patients receiving HPN for malignant intestinal obstruction can survive more than three months. The median and mean survival length was found to be 83 days and 116 days, respectively (55% mortality at three months and 76% mortality at six months, respectively) [36]. These data are in keeping with those of a large prospective multinational case series of 414 patients on HPN, 67% of whom had intestinal obstruction, (median survival 91 days, 50% mortality three months and 77% mortality at six months) [37].

The clinical challenge is to accurately identify those patients who are likely to survive long enough to benefit from HPN treatment. Recently, a nomogram has been developed from variables recognized as independent prognostic factors (Glasgow prognostic score, presence and site of metastases and Karnofsky performance status), aimed at estimating the 3-, 6-months and overall survival of incurable aphagic cachectic cancer patients considered for HPN [38].

It is noteworthy that the authors of a recent Cochrane review [39] concluded that they were very uncertain whether total HPN improves length of life in people with malignant bowel obstruction, largely as a result of the lack of published evidence. However, the authors reached these conclusions after applying strict Cochrane methodology (allocation concealment, comparability of treatment groups, blinding of participant and personnel) when reviewing the literature; this approach may be appropriate for evaluating medication efficacy, but may be less applicable to assessing the role of essential nutrition [40].

Six prospective studies [41–46] on HPN-dependent patients for  $\geq 1$  month showed a benefit on health related quality of life (QoL) measured by validated tools (EORTC QLQ-C30 or FACT-G, or TIQ). There are three RCT evaluating the impact of HPN in patients outcome [47–49], with the largest [48,49] reporting an improvement in energy balance and, as-treated analysis, prolonged survival, increased body fat and a greater maximum exercise capacity. The most recent RCT [50] comparing the effects of 6-month HPN to ‘best nutritional care’ in cachectic gastrointestinal cancer patients reported that HPN maintained or increased fat-free mass and improved QoL. It is noteworthy that a group of experts has identified QoL as one of the most important outcome indicators of HPN in cancer patients [51].

Specific contraindications for HPN support in cancer patients include [33]:

- patients who are not adequately informed about the aims of HPN, of its limited benefits and potential complications
- patients who are not informed of their predicted prognosis, or of the possibility of changing/withdrawing the treatment when it becomes futile
- patients who are not sufficiently metabolically stable to be discharged home on PN

### Recommendation 5

**HPN can be considered for patients without intestinal failure who are not able or do not want to meet their nutritional requirements via the oral/enteral route. The patient should be clearly informed about HPN benefits and risks.**

**Grade of Recommendation GPP – Consensus (89.5% agreement)**

#### Commentary

HPN surveys and registries report a percentage of cases who were not categorized as having either benign or malignant intestinal failure (Table 6) [52–57]. These may include patients needing artificial nutritional support who refused - or were not able to cope with - otherwise effective and clinically-recommended EN [58].



**Table 6**  
Indications for HPN in adult patients in different countries according to data from national registries and surveys.

National report, year (ref #)	Total Patients (n.)	Benign GI disease (%)	Cancer on treatment (%)	Cancer-palliative (%)	Others (%)
SPAIN (SENPE Registry), 2016 [52]	256	44	10	25	Not specified, 21
US (ASPEN Registry), 2011–2014 [53]	1064	89	3	0.5	Malnutrition, 4.5 Neurological swallowing disorder, 0.1
UK (BANS report) 2015 [54]	1144	81.5	18.5		Not specified, 2.9 Indications for HPN in the total cohort: - Short bowel, 47 - Fistula, 8 - Malabsorption, 20 - GI obstruction, 10 - DR-Malnutrition, 6% - Swallowing Disorder. or Anorexia, 1 - Others, 8
ITALY (SINPE survey), 2012 [55,56]	46.1 (/10 <sup>6</sup> inhabitants)	20	61		Neurological disease, 12% Not specified, 7
CANADA (CNS Registry), 2011–2014 [57]	187	66	34		

GI, gastrointestinal; DR, disease-related.

Such patients may have cancer and an indwelling CVAD for chemotherapy; alternatively, they may have dysphagia and elect not to have EN [59–61]. Since it is difficult to deny nutritional support in clinical practice, HPN can sometimes be prescribed in these settings. Patients without CIF who are not able or do not want to meet their nutritional requirements via the oral/enteral route should be fully informed about the risks of PN therapy, which will likely be higher (including life-threatening risks related to HPN) than EN in this setting [3,4,58].

3. What are the criteria for a safe HPN program?

#### Statement 1

**For a safe HPN program, the patient and/or the patient's legal representative have to give fully informed consent to the treatment proposed.**

**Strong consensus (95.7% agreement)**

#### Statement 2

**For a safe HPN program, the patient has to be sufficiently metabolically stable outside the acute hospital setting.**

**Strong consensus (91.3% agreement)**

#### Statement 3

**For a safe HPN program, the patients home environment has to be adequate to safely deliver the therapy proposed.**

**Strong consensus (95.7% agreement)**

#### Statement 4

**For a safe HPN program, the patient and/or the caregiver has to be able to understand and perform the required procedures for the safe administration of therapy.**

**Strong consensus (95.7% agreement)**

#### Recommendation 6

**The patient and/or the caregiver should be trained by a NST to safely infuse the PN with appropriate monitoring and prompt recognition of any complications.**

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

#### Recommendation 7

**The prescribed nutritional admixture and ancillaries required for safe and effective therapy should be delivered by an experienced/certified health care provider.**

**Grade of Recommendation GPP – Strong consensus (95.7% agreement)**

#### Recommendation 8

**The NST should provide appropriate monitoring and treatment for routine and/or emergency care, with appropriate**

**contact details provided to the patient 24 h per day, seven days per week.**

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

#### Commentary

HPN is a complex, life-saving therapy that may result in serious harm if not properly prescribed, prepared and administered. The aims of an HPN program include provision of evidence-based therapy, prevention of HPN-related complications such as catheter-related bloodstream infection (CRBSI) and metabolic complications, as well as ensuring QoL is maximized [3,4]. The HPN program shall provide an individualized, safe, effective and appropriate nutrition support plan at discharge from hospital which should then be supervised and evaluated on a regular basis in the community [62,63].

Previous guidelines and standards recommend that prescription, implementation and monitoring of an individualized HPN program shall be managed by a NST in centers with HPN management expertise [3,10,51,64–74]. Patients managed by such a dedicated patient-centered NST have better outcomes and possible lower overall costs of care [22,64].

The overall care plan includes a variety of pre-discharge and post-hospital care assessments that require coordination between several health-professionals and care providers within and outside the hospital (Table 7). In addition, besides involvement of the key-members of a NST (physician, dietician, nurse, pharmacist), specific patients will require input from physiotherapy, psychology and occupational therapy colleagues [3,67–70]. Communication with the caregivers at home (especially the home care nurse) and in the hospital seems to be a key-factor for patients [62,70]. An experienced and certified health care provider is also required for the appropriate delivery of nutritional admixture and ancillaries to patient's home. The 'adequate' metabolic and clinical stability of a patient can be assessed by vital parameters, energy, protein, fluid and electrolyte balances and glycemic control; here, the term adequate means no immediate risk of acute imbalance after hospital discharge.

If the patient can achieve a stable HPN regimen and his/her overall clinical condition is acceptable, an education program for patients and/or caregivers should be initiated to teach correct and proper HPN care.

The home care environment should be assessed before the education program starts.

**Table 7**

Items to be included in the assessment at patient discharged on HPN [63,74].

- Medical, physical, psychological and emotional suitability/stability of the patient
- Stability of the PN regimen (dosage and admixture)
- Level of home care and support required
- Lifestyle/activities of daily living
- Rehabilitative potential
- Potential for QoL improvement
- Potential for learning self-management of HPN (patient/caregivers)
- Knowledge and experience of the home nursing team (if no self-management)
- Basic home safety, facilities and general cleanliness instruction
- Need for extra equipment (e. g. backpack, infusion pump, hospital bed, extra drip stand)
- Home care provider of nutritional admixture, equipment and ancillaries
- Reimbursement for bags, services and supplies
- Around the clock (on-call) availability of an experienced home care provider
- Post-discharge monitoring necessities/possibilities (including scheduled laboratory tests)
- Medication prescription with administration details

## 2. CVAD and infusion pump

### 4. Which CVAD should be chosen?

#### Recommendation 9

**The choice of CVAD and the location of the exit site shall be made by an experienced HPN NST, as well as by the patient.**

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

#### Recommendation 10

**The exit site of the CVAD should be easily visualized and accessible for self-caring patients.**

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

#### Recommendation 11

**Tunneled CVAD or totally implanted CVADs shall be used for long-term HPN.**

**Grade of Recommendation GPP – Strong consensus (90.9% agreement)**

#### Recommendation 12

**Access to the upper vena cava should be the first choice for CVAD placement, via the internal jugular vein or subclavian vein.**

**Grade of Recommendation B – Strong consensus (100% agreement)**

#### Recommendation 13

**Right-sided access should be preferred to the left-sided approach to reduce the risk of thrombosis.**

**Grade of Recommendation B – Strong consensus (95.2% agreement)**

#### Recommendation 14

**The tip of the CVAD should be placed at the level of the right atrial-superior vena cava junction.**

**Grade of Recommendation B – Strong consensus (100% agreement)**

#### Commentary

The literature search did not add any new information relating to this question when compared to the previous ESPEN guideline for CIF in adults [4]. The process of choosing a CVAD for HPN must involve the patient and the NST, including the specific professional (e.g. anaesthetist, radiologist or surgeon) responsible for placing the CVAD [76,77]. The patient should be involved in choosing the location of the cutaneous exit site which should, of course, also facilitate optimal self-care [78]. Proximity to wounds, prior exit sites, tracheotomies, stomas or fistulae should be avoided. Tunneled CVAD (such as Hickman, Broviac or Groshong) or totally implantable devices (port) are usually chosen for long-term HPN (>6 months) [3]. A single lumen CVAD is preferred, as infections have been reported to occur more frequently with multiple lumen CVAD [73,79,80].

The risk of venous thrombosis is reduced with right vs. left-sided CVAD insertion [81] and, regardless of the type of catheter used and the insertion side, when the CVAD tip is located at the superior vena cava-right atrium junction [81–83].

#### Recommendation 15

**Peripherally inserted central venous catheters (PICCs) can be used if the duration of HPN is estimated to be less than six months.**

**Grade of Recommendation 0 – Strong consensus (100% agreement)**

#### Commentary

ESPEN and ASPEN guidelines [4,84] for CIF do not recommend PICCs for long-term HPN. However many series have reported successful use of PICCs for up to four years [53,57,85–92].

The concern of long term PICC use relates to the putative risk of catheter-related vein thrombosis and CRBSI compared to tunneled CVADs. A study comparing PICCs with other CVADs in long-term HPN found no difference in the CRBSI rate, a higher frequency of catheter removal because of venous-thrombosis and a shorter time between catheter insertion and the first complication in the PICC cohort [89]. A meta-analysis of comparative studies showed a lower rate of CRBSI in HPN patients using PICCs; however, no difference between PICC and tunneled CVADs was observed when the single-arm studies were analyzed [93].

In summary:

- a) better description of the reasons for placement and outcomes of long-term PICC use in routine clinical practice is required
- b) PICCs seem to be associated with a lower risk of CRBSI and a possible higher risk of catheter-related venous thrombosis;
- c) the time to the occurrence of the first catheter-related complication seems to be shorter with PICCs.

### 5. Which infusion control devices should be used for HPN?

#### Recommendation 16

**HPN should be administered using an infusion pump for safety and efficacy reasons.**

**Grade of Recommendation GPP – Strong consensus (91.3% agreement)**

#### Recommendation 17

**In exceptional circumstances a flow regulator can be temporarily used for HPN; administration sets with only a roller clamp should not be used.**

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

#### Commentary

The introduction of infusion pumps has been one of the major technologic advances for the safe administration of PN [94]. An

infusion pump is a medical device that delivers fluids, such as nutrients and medications, into a patient's body in controlled amounts [95]. The use of an electronic (ambulatory) infusion pump with compatible delivery sets is considered as good practice [6,96,97]. Because of the (large) fluid volume, the hypertonicity of the PN admixture and the amount of glucose and potassium delivered, rapid administration or 'free flow' can potentially cause serious harm [97].

It is therefore strongly recommended to use this device whenever possible to manage and monitor the delivery of HPN [3,4,6,13,51,98]. The characteristics of a safe and effective infusion pump for HPN are described in Table 8.

#### Recommendation 18

**A portable pump can improve the patient's QoL when compared to stationary pumps.**

**Grade of Recommendation 0 – Strong consensus (95.7% agreement)**

#### Commentary

Two studies on the use of portable infusion pumps found that the ambulatory pump enabled HPN patients to gain independence [99,100]. Benefits included maintaining desired flow, low noise, long battery life as well as increased probability of social and working rehabilitation and of good QoL. If an ambulatory pump is not available (or appropriate because of the patient's condition), a standard volumetric pump with an intravenous stand is an alternative [4].

### 3. Infusion line and catheter site care

6. Which should be the appropriate infusion line management?

#### Recommendation 19

**Either a sterile gauze or sterile, transparent, semipermeable dressing should be used to cover the CVAD exit site.**

**Grade of Recommendation B – Strong consensus (90.9% agreement)**

#### Recommendation 20

**When transparent dressings are used on tunneled or implanted CVAD exit sites, they can be replaced no more than once per week (unless the dressing is soiled or loose).**

**Grade of Recommendation 0 – Strong consensus (95.5% agreement)**

#### Recommendation 21

**A tunneled and cuffed CVAD with a well healed exit site might not require dressing to prevent dislodgement. Grade of**

**Recommendation GPP confirmed – Strong consensus (100% agreement)**

#### Commentary

The purpose of a dressing is to secure the CVAD, as well as providing barrier protection from microbial colonization and infection. Different kinds of dressings can be used for protecting the CVAD site, including (semi-permeable) transparent polyurethane dressings and gauze and tape. Transparent dressings permit continuous visual inspection of the CVAD site and require less frequent changes unless the dressing becomes damp, loose, or visibly soiled. If there is visible pus exuding from the exit or the site is bleeding, it is better to use a gauze dressing (may be replaced every two days or sooner) until the problem is resolved [73].

A recent systematic review included eight studies with patients in adult bone marrow transplantation (n = 101), hemodialysis (n = 138), gastroenterological (n = 72), adult ICU (n = 21), pediatric and adult oncology units (n = 98) and general wards (n = 76) and reported that there was no clear difference between gauze and tape and polyurethane dressings on the incidence of CRBSI. All included studies had a high risk of performance bias and were of low quality evidence [101]. A previous systematic review came to the same conclusion but the quality of the included studies was also low with small sample sizes and underpowered studies comparing different types of dressings [102]. Finally, in an older systematic review, the use of transparent dressings on CVAD was significantly associated with an elevated relative risk of catheter tip infection (RR = 1.78; 95% CI, 1.38 to 2.30) compared with gauze dressings [103].

The frequency of dressing change also remains a question of some debate. In a multicenter study, 399 bone marrow transplant patients with a tunneled CVAD (n = 230) were randomly allocated to receive CVAD polyurethane dressing changes at different time intervals (Group 1: every two or five days, Group 2: every five or ten days). There was no difference in the rate of local infection but more skin toxicity was reported in the group with shorter interval dressing changes [104]. Nevertheless, a recent systematic review concluded that there is currently inconclusive evidence as to whether longer intervals between CVAD dressing changes are associated with more or less CVAD-related infections [105].

After the healing period (+/- 3 weeks), it remains unclear if a dressing is necessary [73]. The recent ESPGHAN/ESPEN/ESPR/CSPEN guideline for pediatric parenteral nutrition access states that a tunneled CVAD with a well-healed exit site does not require dressing to prevent dislodgement (GPP); however, in children it is useful to have CVADs looped and covered [106].

**Table 8**

Necessary features for an HPN infusion pump [4,6,95,97].

- Easy to clean (splash-proof)
- Operating silently
- User friendly interface (display/keyboard)
- Portability: it should maximize patient's mobility (e.g. possibility to carry it in a backpack together with the PN-bag)
- Availability of a variety of pump-compatible sets with different line lengths
- Rechargeable battery pack(s) with several hours operating time
- Safety features:
  - audible and visual alarms
  - self-test at power-up
  - upstream and downstream occlusion alarms
  - anti-free flow control
- Easy to use instructions
  - Safe operation
  - Alarm silencing, modification, disabling
  - Programmable mode options that include ramp-up/ramp-down and continuous infusion modes
  - Option to "lock out" those infusion modes not required and control the panel lock to prevent accidental or child tampering
- Wireless interface (optional):
  - Infusion parameters remotely controlled
  - Pre-warnings or warnings on mobile phones
- Service and maintenance contract provided, with regular testing of proper functioning



A dressing could also potentially act as a reservoir for pathogens. One study tested this hypothesis by removing the CVAD exit site (gauze) dressing. Seventy-eight individuals with cancer and newly inserted CVADs, stratified for gender (37 men and 41 women) and transplant status, were recruited and randomly assigned to receive either a gauze dressing or no dressing, once their CVAD insertion site had healed (three weeks). There was no significant difference in CRBSI episodes ( $p = 0.28$ ) or rehospitalization rates ( $p = 0.41$ ) between the dressing and no-dressing group, but individuals in the dressing group developed CRBSI sooner ( $p = 0.02$ ) than did individuals in the no-dressing group [107].

#### Recommendation 22

**Tubing to administer HPN should be replaced within 24 h of initiating the infusion.**

**Grade of Recommendation B – Strong consensus (100% agreement)**

##### Commentary

PN is considered as a medium where several factors may influence microbial growth leading to CRBSI risk [108]. In a prospective, randomized study, an intention-to-treat analysis demonstrated a higher level of intravenous tubing (administration set) colonization in tubes changed every 4- to 7-days vs. those only changed every 3-days; however, the two groups had a comparable rate of colonization when patients receiving PN ( $n = 84$ ) were excluded from this study [109]. Another randomized trial specifically involving PN infusion, found that changing tubing every 4 days vs. every 2 days did not impact on hub contamination and CRBSI rates [110]. A Cochrane systematic review found: a) no evidence to demonstrate that CRBSI rate was affected by frequent changes of non-lipid containing tubing; b) some evidence suggesting that mortality increased within the neonatal population with infrequent giving set replacement. However, much of the evidence evaluated in this Cochrane review was derived from studies of low to moderate quality [111,112].

Currently there is no evidence that it is safe to extend the period of administration sets that contain lipids beyond an interval of 24 h and this is generally accepted as best practice [111,112]. Furthermore, the Center for Disease Control and Prevention (CDC) consider PN as an independent risk factor for CRBSI and recommend infusion set replacement after 24 h [73]. Given that HPN patients are very often on cyclic PN, infusion sets normally will be replaced every 24 h.

#### Recommendation 23

**Strict aseptic technique for the care of home CVAD shall be maintained.**

**Grade of Recommendation A – Strong consensus (100% agreement)**

##### Commentary

A recent systematic review revealed that there is not enough evidence to confirm whether patients receiving PN are more at risk of developing CRBSI than those who did not receive PN therapy [113]. Nevertheless, CRBSI is a common complication in patients receiving HPN. In a study of 172 adult HPN patients, 94 CRBSIs were diagnosed on 238 CVADs. Previous catheterizations and the presence of an enterocutaneous stoma were significantly related with a higher infection risk [114]. In another study with HPN patients, 465 CRBSIs developed in 187 patients (18%) during the three years study period [115].

Cotogni et al. [116] reported that the incidence of CRBSIs is low (0.35/1000 catheter-days), particularly for PICCs (0/1000;  $P < 0.01$  vs Hohn and tunneled catheters) and for ports (0.19/1000;  $P < 0.01$  vs Hohn and  $P < 0.05$  vs tunneled catheters)

A systematic review in adult patients receiving HPN showed an overall CRBSI ranged between 0.38 and 4.58 episodes/1000

catheter days (median 1.31). Gram-positive bacteria of human skin flora caused more than half of infections [117].

#### Recommendation 24

**Hand antisepsis and aseptic non-touch technique should be used when changing the dressing on CVADs.**

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

##### Commentary

Hand antisepsis is the most important measure to prevent contamination. Using gloves does not obviate the need for hand antisepsis. Gloves can be used when contact with blood, body fluids, secretions and excretions can be anticipated. The CDC leaves the choice of using gloves to local or federal regulations, rules, or standards [73]. There is only indirect evidence demonstrating the use of non-sterile gloves is not inferior to sterile ones even in more invasive procedures such as minor skin excisions and outpatient cutaneous surgical procedures, [118,119].

#### Recommendation 25

**A 0.5–2% alcoholic chlorhexidine solution shall be used during dressing changes and skin antisepsis; if there is a contraindication to chlorhexidine, tincture of iodine, an iodophor, or 70% alcohol shall be used as an alternative.**

**Grade of Recommendation A – Strong consensus (95.2% agreement)**

##### Commentary

There is a body of evidence that demonstrates that the incidence of CRBSI is significantly reduced in patients with CVAD who receive chlorhexidine gluconate versus povidone-iodine for insertion-site skin disinfection [73,120–124]. This is also the reason why chlorhexidine is mentioned in most checklists for CVAD insertion [125].

#### Recommendation 26

**Hand decontamination, either by washing hands with soap and water but preferably with alcohol-based hand rubs, should be performed immediately before and after accessing or dressing a CVAD.**

**Grade of Recommendation B – Strong consensus (95.2% agreement)**

##### Commentary

Hand decontamination is a key factor in the prevention of health-care related infections which includes CVAD-related infections [73]. Several products are available: alcohol-based decontamination, non-alcohol-based decontamination, antimicrobial/antiseptic hand-washes or agents or liquid soap and water. Before using a hand-rub solution, hands should be free from dirt and organic material. The solution must come into contact with all surfaces of the hand. The hands must be rubbed together vigorously, paying particular attention to the tips of the fingers, the thumbs and the areas between the fingers, until the solution has evaporated and the hands are dry. This should be done immediately before and after direct patient care or contact and after removal of any gloves [126].

Results from a systematic review supported the use of alcohol-based hand rubbing: it removed microorganisms effectively, required less time and irritated hands less often than did hand-washing with soap or other antiseptic agents and water [127]. Furthermore, the availability of bedside alcohol-based solutions increased compliance with hand hygiene among health care workers [127]. Other randomized trials also favored the use of alcohol-based solutions [128,129].

#### Recommendation 27

**A needle-free connector should be used to access intravenous tubing.**

**Grade of Recommendation B – Strong consensus (100% agreement)**

**Recommendation 28**

**Needle-free systems with a split septum valve may be preferred over some mechanical valves due to increased risk of infection with mechanical valves.**

**Grade of Recommendation 0 – Strong consensus (100% agreement)**

**Commentary**

Needleless connectors are an easy access point for infusion connection. They were introduced and mandated to prevent needlestick injuries, reducing the risk of transmission of blood-borne infections to healthcare personnel [73]. In several studies, the use of needleless connectors appears to be effective. Compared to the use of standard caps or 3-way stopcocks, they can reduce internal microbial contamination and so the incidence of CRBSI, but they have to be properly disinfected [130–132].

The majority of needleless connectors fall into one of two categories; namely those with no moving internal parts (e.g. an external split septum) and connectors which moving internal components. Based on available data, split septum connectors should be preferentially used instead of mechanical valves [73,133]. The issue becomes more complicated when the risk of (tip) occlusion due to negative displacement or blood reflux is also taken into account, depending on the type of connector used [134]. Needleless connectors have to be changed no more frequently than every 72 h or according to manufacturers' recommendations [73].

**Recommendation 29**

**Contamination risk shall be minimized by scrubbing the hub connectors (needleless connectors) with an appropriate antiseptic (alcoholic chlorhexidine preparation or alcohol 70%) and access it only with sterile devices.**

**Grade of Recommendation A – Strong consensus (100% agreement)**

**Recommendation 30**

**For passive disinfection of hub connectors (needleless devices) antiseptic barrier caps should be used.**

**Grade of Recommendation B – Strong consensus (90.9% agreement)**

**Commentary**

Needleless connectors are used on virtually all CVAD, providing an easy access point for infusion connection. Infection guidelines strongly recommend proper disinfection of access ports [135]. A systematic review revealed that the greatest risk for contamination of the CVAD after insertion was the needleless connector, with 33–45% contaminated, and compliance with disinfection was as low as 10%, but the optimal technique or disinfection time were not identified [136]. Another systematic review recommended scrubbing with chlorhexidine-alcohol for 15 s [137]. However, if the membranous septum of a needleless luer-activated connector is heavily contaminated, conventional disinfection with 70% alcohol does not reliably prevent entry of microorganisms [138]. Since compliance with a time-consuming manual disinfection process is low, the use of an antiseptic barrier cap (placed on a luer needleless connector), which cleans the connection surface by continuous passive disinfection, was associated with a decrease in CRBSI [138,139].

**Recommendation 31**

**If HPN is delivered via an intravenous port, needles to access ports should be replaced at least once per week.**

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

**Commentary**

An implanted intravenous port is a small device with direct access to a central vein, used to draw blood and give treatments, including intravenous fluids, drugs, blood transfusions and PN. The port is placed just underneath the skin, usually in the chest. A

catheter is attached to a subcutaneous pocket (made of titanium) with the tip ending at the right atrial-superior vena cava junction. To gain access, a needle is inserted through the skin and the rubbery self-healing membrane of the port. The CDC guideline considers the timeframe to replace needles as an 'unresolved' issue [73]. There is also a possible higher risk of colonization of administration sets with PN. On the other hand, one retrospective study demonstrated that weekly changing of exit-site needles and transparent dressings on intravenous ports seems to be safe and cost-effective but, in this study, patients on PN had a significantly greater risk of developing an infection from *Candida* Species [140]. In a study with patients on continuous chemotherapy, needles were in place for an average of 28 days without adverse effect [141]. Because there is no clear evidence, we suggest replacing port needles at least once-a-week with the use of PN. This also gives the opportunity for some patients to safely take a bath or shower when the needle has been removed and replaced afterwards.

**Recommendation 32**

**The CVAD or CVAD site should not be submerged unprotected in water.**

**Grade of Recommendation B – Strong consensus (95.2% agreement)**

**Commentary**

A study in children suggested that swimming did not increase the risk of tunneled CVAD-related infections [142]. No firm recommendation could be made in a review of 45 articles and 16 pediatric HPN programs regarding swimming and CVADs but the authors also reported a fatal event immediately after swimming [143]. Using a closed-hub system and waterproof catheter hub connections significantly reduced the incidence of CRBSIs (particularly infections caused by gram-negative pathogens) in another group of pediatric patients [144].

The CDC guidelines (recommendation B) allow showering if precautions can be taken to reduce the likelihood of introducing organisms into the catheter (e.g. if the catheter and connecting device are protected with an impermeable cover during the shower) [73]. The ESPGHAN/ESPEN/ESPR/CSPEN guideline for pediatric PN access allows swimming (GPP) when a water-resistant dressing is used to cover the whole catheter and, after swimming, the exit site should be cleaned and disinfected [106].

**Recommendation 33**

**Sodium chloride 0.9% instead of heparin should be used to lock long-term CVAD.**

**Grade of Recommendation B – Strong consensus (95.5% agreement)**

**Commentary**

Historically, heparin was the most commonly used catheter lock solution. However, a retrospective study [145], a randomized prospective study [146] and two systematic reviews [147,148] demonstrated that normal saline flushing is not inferior to heparin flushing regarding CVAD occlusion, reflux dysfunction and flow dysfunction. ASPEN guidelines state that "no recommendations can be made as to which flush solution should be used to maintain patency for HPN CVAD due to the lack of studies" [84].

For the primary prevention of CVAD-related venous thrombosis, ESPEN guidelines for CIF recommend insertion of the catheter using ultrasound guidance and placement of the tip at the superior vena cava-right atrium junction, suggest flushing CVAD with saline and do not recommend routine thromboprophylaxis with drugs (heparin, warfarin) [4]. ESPEN guidelines for CIF do not recommend heparin for the prevention of CRBSIs [4], because it promotes intraluminal biofilm formation and therefore potentially increases the risk of CRBSIs [149,150]. German guidelines give a GPP grade for their recommendation of using saline and a grade B for their recommendation of not using heparin [11]. A grade B

recommendation for the use of saline instead of heparin to flush and lock the CVAD is appropriate, given that this approach does not increase the risk of CVAD occlusion and has a lower risk of biofilm formation in the CVAD lumen.

#### **Recommendation 34**

**As an additional strategy to prevent CRBSIs, taurolidine locking should be used because of its favorable safety and cost profile.**

**Grade of Recommendation B – Strong consensus (100% agreement)**

#### **Commentary**

For the primary prevention of CRBSI, ESPEN guidelines for CIF [4]:

- a) recommend education of staff and patients/caregivers; implementation of an adequate policy of hand washing and disinfection by patients and staff; handwashing and disinfection by patients and caregivers before touching CVAD as well as after CVAD care; disinfection of the hub connector every time it is accessed; use of tunneled single-lumen catheters whenever possible; use of chlorhexidine 2% for antisepsis of hands, CVAD exit site, stopcocks, catheter hubs and other sampling ports and regular change of IV administration sets.
- b) suggest performing site care, including catheter hub cleaning on at least a weekly basis; changing CVAD dressings at least once weekly; avoiding CVAD care immediately after changing or emptying ostomy appliances and disinfecting hands after ostomy care.
- c) do not recommend the use of in-line filters; routine replacement of CVADs; antibiotic prophylaxis and heparin lock.

ESPEN guidelines for CIF were published in 2016. Since then, no additional relevant literature was found concerning the above recommendations, but two high quality double blinded RCTs [151,152] and one extensive retrospective analysis [153] have been published on antimicrobial CVAD locking with various taurolidine formulations, that have considerably changed the available body of evidence and the strength of recommendation about the use of taurolidine for the prevention of CRBSI. All studies were performed in the setting of HPN support for adult benign CIF. Tribler et al. investigated CVAD locking with taurolidine 1.4%-citrate-heparin in comparison to control (low-dose heparin 100 IE/mL) in a single center study in 41 high-risk Danish HPN patients who had been stratified according to their prior CRBSI incidence [151]. In 20 patients who received the taurolidine-containing formulation, no CRBSIs occurred in contrast to CRBSIs in 7 out of 21 controls (incidence 1.0/1000 CVC days;  $p < 0.05$ ). Costs in the taurolidine arm were lower because of fewer admission days related to CRBSI treatment.

Since locking with heparin solutions has been suspected of promoting CRBSI, Wouters et al. compared a pure taurolidine 2% lock to another control (saline 0.9%) in a multicenter trial [152]. Patients were stratified in a new catheter group and a pre-existing catheter group. Overall 102 patients were analyzed. In the new catheter group, CRBSIs/1000 catheter days were significantly lower (0.29 vs 1.49) in the taurolidine arm while in patients who entered the trial with a pre-existing catheter CRBSI rates were also lower in the taurolidine arm (0.39 vs 1.32;  $p > 0.05$  due to under-powering). Mean costs per patient were significantly lower for taurolidine. Drug-related adverse events were rare and generally mild.

Wouters et al. also retrospectively analyzed long-term complications and adverse events in adult HPN patients from a national referral center who all used taurolidine locks between 2006 and 2017 [153]. In total, 270 HPN patients used taurolidine during 338,521 catheter days. CRBSIs, catheter related venous thrombosis

and occlusions occurred at rates of 0.60, 0.28, and 0.12 events per 1000 catheter days, respectively. In 24 (9%) patients, mild to moderate adverse events resulted in discontinuation of taurolidine. A subsequent switch to 0.9% saline resulted in an increased CRBSI rate (adjusted rate ratio 4.01,  $P = 0.02$ ). Several risk factors were identified for CRBSIs (including lower age and increased infusion frequency), thrombosis (site of vein insertion), and occlusions (type of access device).

#### **Recommendation 35**

**If a PICC is used for HPN, a sutureless device should be used to reduce the risk of infection.**

**Grade of Recommendation B – Strong consensus (100% agreement)**

#### **Recommendation 36**

**For the securement of medium- to long-term PICCs (> 1 month) a subcutaneously anchored stabilization device can be used to prevent migration and save time during dressing change.**

**Grade of Recommendation 0 – Strong consensus (100% agreement)**

#### **Commentary**

A prospective study with 254 HPN patients revealed that use of sutureless devices for CVAD securement decreased the risk of CRBSI and dislocation ( $p < 0.001$ ) [116]. A multiple treatment meta-analysis found that sutureless securement devices were as likely to be the most effective at reducing the incidence of CRBSI but the quality evidence was low [101]. For the securement of medium-to long-term PICCs, a subcutaneously anchored stabilization device can be used; it seems safe and cost-effective [154]. In the UK, the National Institute for Health and Care Excellence (NICE) recommends the adoption of this device (SecurAcath) for securing PICCs within the National Health Service in England [155]. Another study demonstrated that the use of SecurAcath saved time during dressing change compared with an alternative securement device (Statlock) but training on correct placement and removal was critical to minimize pain [156]. Besides sparing time during dressing change, it also can prevent migration of the PICC [157].

#### **Recommendation 37**

**In multilumen catheters, a dedicated lumen should be used for PN infusion.**

**Grade of Recommendation GPP – Strong consensus (95.5% agreement)**

#### **Commentary**

A previous ESPEN guideline recommended use of a single-lumen CVAD or of a dedicated lumen on a multilumen CVAD for PN administration [9]. The CDC guidelines gave no recommendation regarding the use of a dedicated lumen for PN [73]. Recently, Australian authors reviewed the available literature for comparative rates of CRBSIs in patients who received their PN in any health setting through a dedicated lumen compared with those who had PN administered through multilumen CVADs from 2286 records that were identified through database searching; they found only two studies that fit inclusion criteria in a qualitative synthesis [158]. These studies included 650 patients with 1349 CVADs showing an equal distribution of CRBSIs between groups [158]. This lack of evidence for the use of a dedicated lumen to reduce infections most likely resulted from the poor way study results were reported with a high risk of bias, indicating the need for well-powered high-quality research in this field. Therefore, the panel of the present guideline strongly agreed to confirm the recommendation made by the earlier ESPEN guidelines [9].

#### **Recommendation 38**

**Routine drawing of blood samples from CVAD should be avoided if possible due to an increased risk of complications.**



## Grade of Recommendation B – Strong consensus (95.2% agreement)

### Commentary

When risk factors for CRBSI occurrence were retrospectively studied in 125 adults who received HPN by reviewing medical records from a national home care pharmacy in patients who used HPN at least twice weekly for > 2 years between 2006 and 2011, it was found in adults (331 CVADs, CRBSI rate 0.35/1000 catheter days) using univariate analysis that the use of subcutaneous infusion ports instead of tunneled catheters ( $p = 0.001$ ), multiple lumen catheters ( $p = 0.001$ ), increased frequency of lipid emulsion infusion ( $p = 0.001$ ), obtaining blood from the CVC ( $p < 0.001$ ), and infusion of non-PN medications via the CVC ( $p < 0.001$ ), were significant risk factors for CRBSI occurrence [159].

Although high quality studies in the field of (H)PN are lacking, indirect evidence from a retrospective multivariate analysis of 452 totally implantable vascular devices in French cystic fibrosis patients that were used for administration of antibiotics, showed that removal, either due to obstruction (21%), infection (9%), septicemia (7%) or vascular thrombosis (5%), could be linked, apart from the CVC material (polyurethane vs silicone), to their routine use for blood sampling (versus never) [160].

## 4. Nutritional admixtures

### 7. Which nutritional PN admixture bag should be chosen?

#### Statement 5

**The HPN-admixture shall meet the patient's requirement.**

**Strong consensus (95.7% agreement)**

#### Recommendation 39

**Either commercially available ready-to-use admixtures or customized and tailored to the individual patient's requirements admixtures can be used for HPN.**

**Grade of Recommendation GPP – Strong consensus (95.7% agreement)**

#### Recommendation 40

**Customized and tailored HPN admixtures can be prepared either by individual compounding or by ready-to-use prepared and adapted commercial multi-chamber bags, according to the manufacturer instructions and using aseptic admixture technique preferably in a laminar flow cabinet.**

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

### Commentary

The PN admixture provided for HPN should meet the individual patient's requirements [3,4]. PN admixtures can be compounded in single bags, dual chamber bags or three in one/all-in-one (AIO) bags (these contain separate compartments for lipid emulsion/glucose/amino acids to be opened and mixed before infusion). Vitamins and trace elements can be added prior to infusion in the home setting, if appropriate compatibility and stability [3,4]. Dual and three chamber bags have advantages for HPN patients as they have a longer shelf life. Some AIO bags do not require refrigeration, which provides advantages for HPN patients while travelling. Stability is also markedly prolonged by refrigeration that requires a dedicated refrigerator for HPN storage [4].

The clinical advantages or disadvantages of individually compounded (“tailored” or “customized”) PN admixture in comparison with commercially available ready-to-use (“premade” or “pre-mixed”) PN admixture adapted to the patient's requirements has been addressed by previous guidelines, but published data did not support definitive recommendations. ESPEN guidelines do not address whether commercial ready to use bags (with or without additions) have any advantages over customized bags in the home setting [3,4]. ASPEN clinical guidelines state that commercial ready

to use bags are considered as an available option for patients alongside customized PN formulations to best meet patients' needs [161]. However, this was based on literature comparing different types of bags in the hospital inpatient setting and not at home. The guideline also states that an evaluation of clinical outcomes, safety and cost should be considered before making the final determination. However, they highlight that most of the controlled clinical trials do not directly compare the use of commercial ready-to-use bags with customized PN systems for patient outcomes, efficacy or safety and focus instead on evaluations following conversion from one delivery approach to another system [161]. German guidelines advocate the use of “all-in-one nutrient mixtures” and advise that multi-bottle systems should not be used because of increased risks and more difficult handling [11,162].

The literature search for this guideline provided eleven articles that were considered to have some relevance to the question of comparison of commercial ready-to-use and customized PN admixture in non-critically ill patients [163–173]. Only one of the eleven articles, a conference abstract, compared different types of PN bags in the homecare setting, with all other articles evaluating the use of PN in hospital inpatients [163]. The results suggested that customized PN may be associated with a lower microbiological risk than commercial ready-to-use bags for patients with CIF; however, differences were not statistically significant and this paper has not been published in full [163]. There were no studies found that compared commercial ready-to-use and customized PN in relation to clinical outcome or cost in HPN patients. There are no data on the use of different nutritional admixtures for people with CIF as result of benign vs. malignant disease.

The results of the studies comparing commercial ready-to-use and customized PN in hospital inpatients may have some relevance for further studies in HPN patients. A number of studies in the hospital setting demonstrated that commercial ready-to-use PN is cheaper than customized PN; this may be due to lower acquisition costs, reduced preparation time and avoidance of costs associated with the development of CRBSI [164–168]. A retrospective study of in-hospital PN found that adding supplements to multi-chamber PN bags on the hospital ward increased blood stream infection risk [169], although this has not been confirmed in other studies [170]. Studies evaluating ready-to-use and customized PN in hospital highlight that the commercial ready-to-use PN may not be suitable for all patients [165,171,172]. A recent systematic review comparing pharmacy compounded PN bags and multi-bottle systems for in-patients noted that methodological factors limited evidence quality and highlighted the need for more prospective studies [173].

Given the paucity of data in the HPN setting, further studies are clearly needed to investigate the cost implications, safety and clinical outcomes of using commercial ready-to-use PN-admixtures for patients with benign and malignant CIF.

### 8. What are the critical steps during the preparation of PN admixtures?

#### Recommendation 41

**Customized AIO admixture stability should be documented for the individual admixture based on checks by appropriate lab methods.**

**Grade of Recommendation B – Strong consensus (100% agreement)**

#### Recommendation 42

**Customized AIO admixture stability shall not be extrapolated from the literature.**

**Grade of Recommendation GPP – Strong consensus (95.2% agreement)**

**Commentary**

AIO stability has to be documented for the individual admixture based on checks by appropriate lab methods. Literature extrapolation for stability is not adequate due to the complexities of the admixtures [11,174,175].

Electrolytes are prone to incompatibilities (precipitations, multi-valent cations and negative charged lipid emulsifier leading to emulsion destabilization). Their correct admixing into the appropriate macro-element component is crucial; in selected cases with a high calcium need, organic instead of inorganic components might be preferable [175]. Easy to use and validated methods may be used to check for stability like for the Oil/Water stability of AIO admixtures [176].

**Recommendation 43**

**AIO admixture shall be completed immediately before infusion by adding trace elements and vitamins according to stability and compatibility data.**

**Grade of Recommendation GPP – Strong consensus (91.3% agreement)**

**Commentary**

AIO admixture shall be completed by adding trace elements and vitamins in aseptic conditions according to stability and compatibility data. For structural/and or organizational reasons, the addition may also be performed immediately before infusion through appropriately trained persons.

In order to prevent incompatibilities, including degradation of essential elements, vitamins may be preferably added by the end of the infusion cycle or as a bolus. Appropriate risk assessment for the Good Manufacturing Practice modalities but also the extent of standardization have to be addressed [11,177,178].

**Recommendation 44**

**Drug admixing into AIO admixture shall be avoided, unless specific pharmaceutical data are available to document compatibilities and stability of the AIO.**

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

**Commentary**

AIO admixtures show a high potential of drug interactions leading to incompatibilities or stability issues. They are normally not suited for drug admixing and, when necessary, the specific pharmaceutical data have to be provided and documented as this final product represents an individual drug product; the product performance and reliability after interaction with drugs is not covered by the manufacturer [176,179].

**Recommendation 45**

**AIO admixtures shall be labelled for the individual patient indicating the composition (dose) of the individual components according to standards, the date, the patient's name and indication for handling such as storage, admixes to be made, infusion rate.**

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

**Commentary**

AIO admixtures have to be labelled for the individual patient. Labels shall indicate the patient's name, the composition (dose) of the individual components according to standards, the date of manufacturing and expiring, instructions for handling like storage, admixes to be made, infusion rate, as well as avoidance of medication errors [177,179,180]. Specific pharmaceutical support within the NST is required and efficacious [181].

9. How should PN admixture be delivered?

**Recommendation 46**

**For customized AIO admixtures, the cold chain should be guaranteed during transport and at the patient's home.**

**Grade of Recommendation B – Strong consensus (100% agreement)**

**Commentary**

Clearly, pharmaceutical safeguards must be applied for PN delivery, storage and administration at home throughout the patient's therapy. For customized AIO PN admixtures, the cold chain has to be guaranteed [175].

10. What should be the HPN admixture time and rate of infusion?

**Recommendation 47**

**The hanging time for an HPN-admixture should be no longer than 24 h.**

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

**Recommendation 48**

**At the end of cyclic PN administration, the infusion rate can be reduced to avoid rebound hypoglycemia (e.g. half of the infusion rate over the last half an hour).**

**Grade of Recommendation GPP – Strong consensus (93.8% agreement)**

**Commentary**

The generally accepted maximum hanging time for a ready-to-use admixture are 24 h. The giving set has to be changed upon each new PN dosing [11,175,178,179].

At the end of a (cyclic) PN-infusion, the infusion rate has to be reduced to temper insulin need and to avoid rebound hypoglycemia (e.g. half of the infusion rate over the last half an hour). Glucose administration determines the maximum rate of PN infusion rate: (max. 5–7 mg glucose/kg/min; corresponding to about a maximum of 350 g glucose over 12 h in 70 kg adult [175,179] or 3–6 g glucose/kg per day [3].

**5. Program monitoring**

11. How should patients on HPN be monitored?

**Recommendation 49**

**Patients receiving HPN shall be monitored at regular intervals, to review the indications, the efficacy and the risks of the treatment.**

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

**Recommendation 50**

**The time between reviews should be adapted to the patient, care setting and duration of nutrition support; intervals can increase as the patient is stabilized on nutrition support**

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

**Recommendation 51**

**HPN monitoring should be carried out by the hospital NST in collaboration with experienced home care specialists, home care agencies and/or general practitioners.**

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

**Recommendation 52**

**Patients and/or caregivers can be trained to monitor nutritional status, fluid balance and the infusion catheter.**

**Grade of Recommendation 0 – Strong consensus (95.7% agreement)**

**Recommendation 53**

**Monitoring should comprise of nutritional efficacy, tolerance of PN, patient/caregiver management of infusion catheter, QoL and quality of care (e.g. CRBSI rate, readmission rate etc.).**

**Grade of Recommendation GPP – Strong consensus (95.7% agreement)**



**Recommendation 54**

**In clinically stable patients on long-term HPN, body weight, body composition and hydration status, energy and fluid balance and biochemistry (hemoglobin, ferritin, albumin, C-reactive protein, electrolytes, venous blood gas analysis, kidney function, liver function and glucose) should be measured at all the scheduled (e.g. every three to six months).**

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

**Recommendation 55**

**In patients on long-term HPN, clinical signs and symptoms as well as biochemical indexes of vitamin and trace metal deficiency or toxicity should be evaluated at least once per year.**

**Grade of Recommendation GPP – Strong consensus (95.7% agreement)**

**Recommendation 56**

**In patients on long-term HPN, bone metabolism and bone mineral density should be evaluated annually or in accordance with accepted standards (e.g. DXA at max. every 18 months).**

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

**Commentary**

The purpose of monitoring is to “secure and improve QoL” of persons on HPN by assessing the nutritional efficacy of the HPN program, preventing and timely diagnosing and treating HPN-related complications and measuring QoL and quality of care [3,4]. Evidence-based guidelines for monitoring are not available due to the lack of published data [3–13]. Only one study has been published reporting monitoring practices for HPN across Europe [16]. The results showed that the majority of centers performed a 3-month monitoring interval for stable patients and emphasized that responsibility for monitoring should be assigned to a designated person on the hospital HPN specialist NST [16]. Prospective studies of the impact of different monitoring regimens on outcomes (including QoL) of HPN are warranted.

Monitoring of HPN patients should be carried out by an experienced hospital NST and by home care specialists as well as by a home care agency with experience in HPN and should also involve the general practitioner. Healthcare professionals should review the indications, route, risks, benefits and goals of nutrition support at regular intervals. In long-term HPN, patients and caregivers should be trained in self-monitoring of their nutritional status, fluid balance and infusion catheter, as well as in recognizing early signs and symptoms of complications and responding to adverse changes in both their well-being and management of their nutritional delivery system.

Parameters to be monitored, frequency and setting of monitoring are indicated in Table 9. The time between reviews depends on the patient, care setting, duration of nutrition support as well as the expected speed with which the impairment of a parameter is likely to occur. Monitoring should be more frequent during the early months of HPN, or if there is a change in the patient's clinical condition. Intervals may increase as the patient is stabilized on nutrition support. Fluid balance requires the most frequent monitoring, especially in the first period after discharge and in patients with short bowel syndrome with a high output stoma or with intestinal dysmotility with recurrent episodes of vomiting. Frequent acute dehydration episodes are responsible for kidney failure and re-hospitalization [182,183]. On the other hand, vitamin and trace metal deficiency may take more time to develop and to present clinical signs and symptoms, so that a six to twelve month interval of assessment is appropriate. However, monitoring of micronutrients is as important as monitoring other parameters, especially in patients on long-term HPN and in those who are undergoing intestinal rehabilitation and weaning from HPN. In the

latter case, while intestinal rehabilitation is associated with maintenance of energy, protein, fluid and electrolyte balance without PN support, this is not necessarily the case for micronutrient balance [4]. Decreasing or totally stopping PN infusion decreases micronutrient supplementation, thus creating a risk for deficiency [4].

After hospital discharge, it is critical that the HPN NST has contact with patients and caregivers on a regular basis, initially every few days, then weekly and eventually monthly as the patient gains confidence. The clinician who is in contact should be prepared to clarify confusing issues and also to follow weight, urine output, diarrhea or stoma output, temperatures before and within an hour of starting the HPN infusion, and general health.

Healthcare professionals have identified incidence of CRBSI, incidence of rehospitalization and QoL as the three major indicators of quality of care HPN patients with either a benign [71] or malignant [51] underlying disease. Survival rate was also considered important when patients with benign disease were considered [184].

**6. Management (nutrition support team, training, emergency, travelling)**

12. Which are the local and personnel preconditions for HPN?

**Recommendation 57**

**The suitability of the home care environment should be assessed and approved by the HPN nursing team before starting HPN, wherever possible.**

**Grade of Recommendation GPP – Strong consensus (91.3% agreement)**

**Recommendation 58**

**A formal individualized HPN training program for the patient and/or caregiver and/or home care nurses shall be performed, including catheter care, pump use and preventing, recognizing and managing complications; training can be done in an in-patient setting or at the patient's home.**

**Grade of Recommendation GPP – Strong consensus (91.3% agreement)**

**Commentary**

The management of PN in the home care setting differs from hospitalized patients because there is a shift in primary responsibility from health care professionals to patients and caregivers. The general goals in the education process are promoting independence with the infusion, (self-) monitoring of HPN, preventing complications and improving or maintaining QoL [3,4] (Table 10). The HPN center NST plays a key role in the individualized decision-making process and guides all the necessary measures or steps which have to be taken [3,10,51,64–74].

Guidelines on core components for (catheter) infection control and prevention, considered as an important outcome indicator in HPN patients, give strong recommendations about the provision of education and training [72,73]. Besides preventing CRBSI and assessing QoL, the overall teaching program has many aspects to deal with and is very often driven by an experienced (nutrition support) nurse who takes the lead and responsibility for this program [3,69].

Training for HPN may be carried out in an in-patient setting or at patient's home and may take several days to weeks depending on patient skills, duration of HPN and underlying condition [3,4,74]. A recent retrospective 5-year evaluation of CRBSI occurrence and CVC salvage outcomes in adult patients requiring HPN managed at a national UK intestinal failure unit, demonstrated that by individual managing, patients can be educated at home which of course reduces hospital length of stay and may be preferable for some patients [75]. Multiple education interventions are possible including one-on-one counselling, teach-back method, written handouts, computer-assisted learning and interactive presentations. All these tools may not eliminate but reduce post discharge helpline contacts

**Table 9**  
Parameters, frequency (after baseline assessment) and setting of monitoring on patients on HPN.

Parameter	Frequency	Setting
General condition	Daily if unstable, twice weekly to once a week if stable	Nurse at home
Body temperature		Patient and/or caregivers
Body weight	Daily if unstable, twice weekly to once a week if stable	In the hospital (outpatient visit)
		Nurse at home
		Patient and/or caregivers
Body mass index	Monthly	In the hospital (outpatient visit)
		Nurse at home
Fluid balance	The frequency and type of parameters will depend on etiology of CIF, and stability of patients	Nurse at home
- Urine output		Patient and/or caregivers only in case of training program
- Stoma output	In case of high stool output (end jejunostomy), the monitoring after the first discharge should be daily, then twice weekly to once a week when stable	
- Number or consistency of stools		
- Presence of edema		
Catheter cutaneous exit site	Daily	Nurse at home
		Patient and/or caregivers only in case of training program
Full count blood	The frequency and type of parameters will depend on etiology of the underlying condition requiring HPN and the stability of patients	At home
C-reactive protein		Verify at each visit
Serum glucose		
Serum and urine electrolytes and minerals (Na, Cl, K, Mg, Ca and P)	Weekly or monthly, then every three to four months when stable	
Serum Urea and Creatinine		
Serum bicarbonates		
Urine analysis		
Serum albumin and prealbumin	Monthly, then every three to four months when stable	At home
		Verify at each visit
Serum liver function tests including INR	Monthly, then every three to four months when stable	At home
		Verify at each visit
Liver ultrasound	Yearly	In hospital
Serum Folate, vitamins B12, A and E	Every six to twelve months	Dosage at home or in the hospital
Serum ferritin iron,	Every three to six months	Dosage at home or in the hospital
Serum 25-OH Vitamin D	Every six to twelve months	Dosage at home or in the hospital
Serum zinc, copper, selenium	Every six to twelve months	Dosage in the hospital
Serum Manganese	Yearly	Dosage in the hospital
Bone densitometry (DEXA)	Every twelve to eighteen months	In the hospital

**Table 10**  
Content of a teaching program for patients/caregivers discharged on HPN [3,10,63,74].

- Indication for HPN: short and/or long-term goals and HPN-regimen
- Issues around informed consent
- Role of the home care provider to provide parenteral formulations, equipment, supplies, and eventually nursing care
- Determine learning abilities and readiness to self-management and self-monitoring
  - If applicable: make a checklist for competencies achieved
- Reviewing evidence-based written policies and procedures complemented with oral instructions
- Home care environment
  - General cleanliness (for example: Is there a clean area for aseptic/sterile procedures?)
  - Presence of animals
  - Basic home safety (telephone access, clean storage for supplies, dedicated refrigerator, toilet-bathroom, sanitary water supply, ...)
- Catheter care
  - Principles of infection control and prevention (including aseptic techniques)
  - Preventing, recognizing and managing catheter related complications
  - Site care
- Storage, handling, inspection of admixtures (e.g. leaks, labels, precipitates, color), ancillaries and (medication) supplies
- If applicable:
  - Safe addition of vitamins, trace elements or other additives
  - Safe administration of HPN
  - Connecting and disconnecting IV tubing to the vascular access device
  - Pre/post infusion flushing
  - Periodically assessment of performance/compliance with aseptic techniques
- Pump use, programming, pump care and troubleshooting
- Preventing, recognizing and managing non-infectious related complications or problems
- Most common mistakes
- Available contact resources and post discharge support from the HPN center as well as the home care provider
- Self HPN monitoring
- Concomitant drug therapy and administration mode (total regimen management)

provided by telephone, videoconference or patient portals [63,68,74].

Multiple education interventions are available including methods such as one-on-one counselling, written or printed

materials, group meetings, demonstrations, videotapes, CDs/DVDs and internet education [3,4]. HPN is a complex therapy that requires coordination of many health care providers. The expertise of a NST is recommended to provide proper and patient-tailored

education or therapy. Self-management and preventing complications are important goals to improve QoL and to avoid unnecessary costs to healthcare.

13. Which are the requirements for the hospital centers that care for HPN patients?

#### **Recommendation 59**

**Patients on HPN should be cared for by specialized, dedicated and a clearly identifiable hospital unit, normally termed “HPN center or IF center or intestinal rehabilitation center”.**

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

#### **Recommendation 60**

**The HPN unit should have offices for outpatient visits and dedicated beds for patients who need hospitalization.**

**Grade of Recommendation GPP – Strong consensus (91.3% agreement)**

#### **Commentary**

The human resources as well as structural facilities are key features to optimize the HPN care.

Specific organization and structural facilities for HPN management have been described by a position statement of the British Intestinal Failure Alliance [12], that described five standards: Unit, Team, Practice, Relationship with other internal and external units/stakeholders and outcome.

Key issues are the identification of the persons, structures and procedures responsible for the HPN care process [4,12,13], such as:

- Professionals who coordinate and manage the different phases of HPN management
- Place of initial care (center of intestinal failure, gastroenterology, surgery, other)
- Place and methods of training programs (on hospital beds, in day hospital, at home)
- Pathways of care in case of complications (example: emergency room, direct access to hospital beds, link with local hospitals of the patient residency)
- Place and procedures for CVAD positioning and managing of complications

Having access to dedicated hospital beds under the responsibility of the NST is essential for initial care as well as for managing of complications. These beds may be within an independent structure of nutrition/intestinal failure or within a more general structure, such as department of gastroenterology, oncology, surgery or other. Hospitalization is required to monitor patients and/or evaluate intestinal function in order to better adapt treatments as well as to timely and appropriately treat complications according to the NST procedures.

The HPN center needs to estimate the time that each professional has to dedicate to the single patient, in order to define the number of human resources required for managing their total number of HPN patients.

In conclusion, for better care and visibility for patients, health-care providers and public authorities, we recommend that departments dedicated to the care of these patients be recognized with dedicated beds and resources.

14. What are the requirements of the NST?

#### **Recommendation 61**

**All HPN patients should be cared for by a NST with experience in HPN management, independent from the underlying disease leading to intestinal failure.**

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

#### **Recommendation 62**

**The NST consists of experts in HPN provision. This can include a physician, specialist nurses (including in catheter, wound and stoma care), dietitians, pharmacists, social worker, psychologist, as well as an appropriate practitioner with expertise in CVC placement. Surgeons with expertise in intestinal failure should also be available for structured consultation.**

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

#### **Commentary**

Because of its complex nature, current guidelines, including the recent ESPEN guideline on CIF, agree that only experienced NST should provide HPN treatment [3–14]. The relevance of expertise in this field has been shown previously in France where increased experience in HPN support had a positive impact on patient survival [185]. To assure optimal outcomes, the team should develop an individualized training and treatment plans based on standardized protocols. Notably, CRBSI rates, which are considered a proxy for the quality of HPN support, even in high-risk patients such as those with cancer, are the lowest in expert referral centers [64,65].

The appropriate composition and size of a NST that provides HPN care to some extent depends on the number of patients under the team's care, which mostly also relates to the patient volume and scope of the hospital [186]. Key tasks of this team include establishing (contra)-indications for HPN support, development and implementation of individualized training and treatment programs, treatment of complications (vascular access related, metabolic derangements) and organization of home care [186].

Also, because of the associated complications of HPN treatment, including venous access-related problems such as infections and occlusions, metabolic derangements, formulation and medication compatibility issues that pertain to various specialties, the team that provides HPN support should be multidisciplinary in nature and include physician specialists with a background in surgery and gastroenterology, specialized nurses, dietitians and pharmacists [66,67]. In light of the profound impact on personal and family life, psychologists and social workers should also form part of the team. This latter issue was highlighted in studies showing that many HPN patients experience the lack of attention for their psychosocial problems as a shortcoming [187,188].

Concerning patients with active cancer, it is important to realize that selecting patients suitable for such a complex treatment as HPN support is challenging and discussion with the treating oncology specialist in this setting seems prudent before HPN initiation [15].

Often forgotten, it is of key importance for patients that caregivers more close to the home, such as the general practitioner and homecare nurses, although not direct team members, should be kept informed of patients' clinical course after discharge from hospital [62,63,68,70]. It has been shown in adult HPN patients who were managed at a national UK referral center that under the well-organized care of such an experienced team in close collaboration with home nurses, even a delicate process such as patient education can take place at home, resulting in reduced hospital length of stay and improved psychosocial wellbeing of both patients and their family [75].

15. How should emergencies be managed?

#### **Recommendation 63**

**The NST for HPN/CIF shall have clear written pathways and protocols in place for the management of patients with complications relating to HPN.**

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

#### **Recommendation 64**

The NST for HPN/CIF shall provide patients and caregivers with written information relating to the recognition and subsequent management of HPN-related complications, including details (e.g. telephone number) of an appropriate NST member to contact in the case of an emergency, available 24 h per day.

**Grade of Recommendation GPP – Strong consensus (91.3% agreement)**

#### Recommendation 65

The NST for HPN/CIF shall disseminate clear protocols relating to the recognition, investigation and initial management of HPN-related complications to hospital emergency departments, where patients are likely to present; where appropriate and available, written protocols can also be carried by the patient or accessed electronically via a secure web-portal.

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

#### Recommendation 66

When patients are admitted to hospital with HPN-related complications, their care shall be delivered by the NST for HPN/CIF; if patients are admitted to a hospital where such expertise does not exist, then clinical guidance should be provided by the NST for HPN/CIF, until the time when the patient can be transferred to the HPN/CIF center, as required.

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

#### Recommendation 67

Written protocols for the management of HPN-related complications shall be developed and shared with the patient's local hospital, if it is likely that the patient will be admitted first to that hospital rather than to the HPN/CIF center in the event of an emergency; these should include contact details for the NST for HPN/CIF to advise on treatment and/or possible transfer to the HPN/CIF center. Where appropriate and available, written protocols can also be carried by the patient or accessed electronically via a secure web-portal.

**Grade of Recommendation GPP – Strong consensus (95.5% agreement)**

#### Recommendation 68

Patients shall carry details relevant to their condition, and/or have access to a secure web-portal containing relevant clinical information, when travelling away from home, in order to aid clinical teams at other hospitals should emergency treatment be required.

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

#### Recommendation 69

The NST for HPN/CIF shall ensure that patients, caregivers and general practitioners are aware of the roles and responsibilities of the health care professionals involved in aspects of the patient's condition that are unrelated to HPN, including any complications relating to the patient's underlying disease and other non-IF related conditions.

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

#### Commentary

Minimal guidance and published literature exist to-date relating to pathways for the emergency management of patients with complications relating to CIF. Such complications should be demarcated into those relating to HPN, those relating to the patient's underlying disease leading to CIF (including any underlying oncological condition) and those unrelated to CIF. The CIF team should ensure that patients and caregivers are aware of the roles and responsibilities of the health care professionals involved in each component of their condition.

There are no published studies that have systematically evaluated best practice for the delivery of emergency care for patients with HPN-related complications, for patients with benign CIF, malignant CIF or no-CIF scenarios. Two studies have demonstrated patient-education programs aimed at minimizing hospital admissions for complications associated with CIF. A retrospective study evaluated the implementation of a protocol to treat dehydration at home for HPN patients by ordering additional intravenous fluids to be kept on hand and to focus patient education on the symptoms of dehydration; this led to a greater than two-fold increase in the number of episodes of dehydration identified and treated at home [183]. Implementation of a CVC self-management education program using a quasi-experimental, sequential cohort design study of patients with cancer led to a reduction in CVC-related complications and improved patients' abilities to resolve problems and adequately respond to CVC-related emergency situations by fostering greater self-care ability; however, this study was not limited to patients with CIF [189]. Two further studies demonstrated that diagnosis and management of CRBSI can be enhanced using quality improvement methodology. An emergency department quality improvement initiative reduced the mean time to antibiotic administration for febrile children with IF by 50%. Interventions included increasing provider knowledge of IF, streamlining order entry, providing individualized feedback, and standardizing the triage process. However, there was no difference noted in the total length of subsequent hospital and ICU stays [190]. Another quality improvement project in a tertiary cancer center involving staff education and blood culture source label introduction improved CRBSI diagnosis from 36% to 88% in patients with a CVC; however, this study was also not limited to patients with CIF [191].

Established national and international guidelines clearly recommend that CIF patients are cared for by a NST with skills and experience in both CIF and HPN management [4]. The British Intestinal Failure Alliance provide some guidelines on the emergency management of HPN-related complications [12]. The NST should be responsible for the management of patients with complications related to HPN, including CVC-related complications and intestinal failure-associated liver disease. This should include the emergency management of any HPN-related issues 24 h per day, seven days per week. Patients and carers must be provided with clear written information relating to the recognition and management of HPN-related complications, including contact details of the NST in case of any emergency. The NST should generate written protocols for the management of HPN-related complications and, importantly, should have systems in-place such that specialist advice from the NST is available at all times. Where patients cannot attend the CIF center with emergency issues (for example, if distance and/or clinical need mandates immediate care at a local hospital), the NST should ensure that shared cared-protocols have been disseminated to local hospitals in advance and that the patient also has relevant details of their condition available.

Patients and caregivers should be aware that the NST may not be responsible for all aspects of their health, including the underlying disease leading to CIF. For example, patients with Crohn's disease may be under the care of a gastroenterologist at a local hospital for the monitoring and management of IBD-related issues. Similarly, for patients with malignancy, oncology and/or palliative care teams best manage emergencies relating to underlying disease. Thus, as soon as a patient is established on HPN, he/she and his/her general practitioner should be made aware of the relevant roles and responsibilities of the health care professionals involved in aspects of the patient's condition that are unrelated to HPN [3,11,14].

Patients can suffer from non-IF related conditions and these can be a significant cause of morbidity and mortality (for example,



cardiac disease, respiratory disease etc.). Care for these conditions, including any emergency needs, should continue as for patients without CIF [3,11,14]. It is important that the NST is informed immediately of any changes in these conditions, including any alterations in medication for non-IF related problems, as well as any admissions to hospital.

16. How should travelling with HPN be organized?

#### **Recommendation 70**

**For a patient to travel safely, he/she shall receive a sufficient supply of PN and relevant ancillaries during the journey and at the destination and the NST responsible for the patient's care shall endeavor to establish contact with a skilled NST at the patient's destination, in case medical support is required.**

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

#### **Commentary**

Patients on long-term HPN may need to learn how to adjust to lifestyle events such as bathing, showering, swimming, sports and travel [12]. Travelling with PN is an important factor for some patients' QoL [192,193] and independency [70,194]. However, none of the previous guidelines and position papers addressed this topic and a literature search did not provide any new information about this area in adults. So the recommendation and comments of the present guideline were based on statements of patients' representatives participating in the panel.

Pre-travel planning is essential to ensure that the patients can meet their usual PN/IV fluid requirements as well as to be able to perform PN-related procedures safely. The patient/caregivers should discuss their travel plans with their healthcare professionals/NST to ensure that they/their child are fit to travel. The doctor should issue a letter/medical certificate for the patient/caregivers confirming that they are aware they are travelling, along with a brief overview of their condition and need for PN. Medical cover/travel insurance should be arranged prior to travelling to ensure that any medical treatment needed while travelling will be possible. The patient/caregivers should ask about the potential and suitability of multi-chamber bags for their trip instead of compounded PN if they would like to consider using them. The patient/caregivers should investigate different power supplies/plugs prior to travelling to ensure they can charge pumps and batteries. A spare infusion pump should be taken on all trips, alternatively check the possibility of a replacement pump at the destination. Using homecare/compounding services at the end destination should be investigated very early during the planning period where reimbursement is possible and is available via different healthcare systems. The patient/caregivers need to calculate the number of fluid bags (PN/IV fluids) and ancillaries/medical supplies that they will need for their trip allowing for extra supplies. It is the responsibility of the patient/caregivers to know the stability of the PN, how long compounded PN can be safely stored in the dedicated PN boxes supplied by homecare companies/hospitals, before it needs to be placed in a fridge. The patient/parents should plan for additional fluids for the duration of travel, where high temperatures may be experienced, to ensure hydration is maintained. All fluids and ancillaries/medical supplies must be appropriately packed to ensure safe storage and stability both in terms of preventing damage and maintaining cold-chain temperatures, where applicable. The type of accommodation should be carefully considered in advance, especially where a fridge is required for the storage of compounded PN at 2° – 8 °C. In case of an emergency situation, a plan of action should be prepared beforehand and all important (doctor, family) contact numbers should be easily accessible. All modes of transport are possible for PN, travelling by plane will require more detailed planning. Attention to increased security checks must be respected. Prior to travel, if any special

arrangements need to be made – such as additional space, extra baggage allowance, security approval – this must be arranged prior to departure. All PN/IV fluid boxes and ancillary/medical supplies baggage should be clearly labelled with a name, destination, date of travel and instructions not to open if cold-chain PN unless in the presence of the patient/caregivers. Usual healthcare professionals should consider establishing local medical support or a contact for the patient should medical support be required.

17. Which criteria should be used to monitor the safety of HPN program provision?

#### **Recommendation 71**

**Incidence of catheter-related infection, incidence of hospital readmission and QoL should be used as criteria to assess the quality of care of HPN program.**

**Grade of Recommendation GPP – Strong consensus (100% agreement)**

#### **Commentary**

Three multicenter international studies have identified and ranked the interventions determined to be essential for good quality of care (also called 'key interventions') [51,71,184]. Two studies were based on the opinions of healthcare professionals with expertise on HPN and included either benign or malignant CIF [51,71]. The third study evaluated the desired outcomes of patients with CIF due to benign disease [70,184]. The two-round Delphi approach was used, which is a technique that transforms opinion into group consensus, and the resulting set of most highly ranked key interventions was then transformed into quality indicators [51,71,184].

The top three outcome indicators identified by healthcare professionals were incidence of CRBSI, incidence of rehospitalizations and QoL for CIF due to either benign [71] or malignant [51] disease. The top three desired outcomes of patients with benign CIF were incidence of CRBSI, survival rate, and QoL on HPN [184].

The key interventions identified should be measured annually in current practice, along with questionnaires on patients' satisfaction, to identify and address any areas for further improvement [4].

According to the Donabedian paradigm [195], the outcome indicators should not be measured alone. The Donabedian model provides a framework to assess the quality of care by working with quality indicators related to structure, process and outcome of health care: 'structure' refers to general administrative standards of the organization and people providing care; 'process' refers to the manner in which care is actually provided and administered; 'outcome' refers to a set of expected or desirable results for patients [195]. Therefore, the outcome indicators reported should be monitored along with the linked process as well as structure indicators which will help to drive quality improvement.

#### **Funding statement**

This guideline was solely financed by ESPEN, the European Society for Clinical Nutrition and Metabolism.

#### **Conflicts of Interest**

The expert members of the working group were accredited by the ESPEN Guidelines Group, the ESPEN Education and Clinical Practice Committee, and the ESPEN executive. All expert members have declared their individual conflicts of interest according to the rules of the International Committee of Medical Journal Editors (ICMJE). If potential conflicts were indicated, they were reviewed by the ESPEN guideline officers and, in cases of doubts, by the ESPEN executive. None of the expert panel had to be excluded from the working group or from co-authorship because of serious conflicts. The conflict of interest forms are stored at the ESPEN



guideline office and can be reviewed by ESPEN members with legitimate interest upon request to the ESPEN executive.

## Acknowledgement

The authors thank Anna Schweinlin for expert assistance in this guideline project.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.clnu.2020.03.005>.

## References

- [1] Cederholm T, Barazzoni R, Austin P, Ballmer P, Biolo G, Bischoff SC, et al. ESPEN guidelines on definitions and terminology of clinical nutrition. *Clin Nutr* 2017;36:49–64.
- [2] Pironi L, Arends J, Baxter J, Bozzetti F, Peláez RB, Cuerda C, et al. Home artificial nutrition & chronic intestinal failure; acute intestinal failure special interest groups of ESPEN. ESPEN endorsed recommendations. Definition and classification of intestinal failure in adults. *Clin Nutr* 2015;34:171–80.
- [3] Staun M, Pironi L, Bozzetti F, Baxter J, Forbes A, Joly F, et al. ESPEN Guidelines on Parenteral Nutrition: home parenteral nutrition (HPN) in adult patients. *Clin Nutr* 2009;28:467–79.
- [4] Pironi L, Arends J, Bozzetti F, Cuerda C, Gillanders L, Jeppesen PB, et al. Home artificial nutrition & chronic intestinal failure special interest group of ESPEN. ESPEN guidelines on chronic intestinal failure in adults. *Clin Nutr* 2016;35:247–307.
- [5] ASPEN Board of Directors and The Clinical Guidelines Task Force. Guidelines for the use of parenteral and enteral nutrition in adult and pediatric patients. *J Parenter Enter Nutr* 2002;26:15A–138SA.
- [6] Gillanders L, Angstmann K, Ball P, Champan-Kiddell C, Hardy G, Hope J, et al. AuSPEN clinical practice guideline for home parenteral nutrition patients in Australia and New Zealand. *Nutrition* 2008;24:998–1012.
- [7] Kovacevich DS, Frederick A, Kelly D, Nishikawa R, Young L. Standards for specialized Nutrition support: home care patients. *Nutr Clin Pract* 2005;20:579–90.
- [8] Koletzko B, Jauch KW, Verwied-Jorky S, Krohn K, Mittal R. Guidelines on parenteral nutrition from the German society for nutritional medicine (DGEM)-overview. *Ger Med Sci* 2009;7:27.
- [9] Pittiruti M, Hamilton H, Biffi R, MacFie J, Pertkiewicz M. ESPEN guidelines on parenteral nutrition: central venous catheters (access, care, diagnosis and therapy of complications). *Clin Nutr* 2009;28:365–77.
- [10] Dreesen M, Foulon V, Vanhaecht K, De Pourcq L, Hiele M, Willems L. Guidelines recommendations on care of adult patients receiving home parenteral nutrition: a systematic review of global practices. *Clin Nutr* 2012;31:602–8.
- [11] Bischoff S, Arends J, Dörje F, Engeser P, Hanke G, Köchling K, et al. S3-Leitlinie der Deutschen Gesellschaft für Ernährungsmedizin (DGEM) in Zusammenarbeit mit der GESKES und der AKE. *Aktuelle Ernährungsmed* 2013;38:e101–54.
- [12] British intestinal failure alliance (BIFA) position statement 2016, home parenteral nutrition. <https://www.bapen.org.uk/images/pdfs/position-statements/position-statement-on-hpn.pdf>.
- [13] NICE guidelines. Nutrition support for adults: oral nutrition support, enteral tube feeding and parenteral nutrition. February 2006. Last updated: August 2017. <https://www.nice.org.uk/guidance/cg32/chapter/1-Guidance#parenteral-nutrition-in-hospital-and-the-community>.
- [14] Intestinal failure service specifications in England. 2018. <https://www.england.nhs.uk/publication/intestinal-failure-service-adult/>.
- [15] Arends J, Bachmann P, Baracos V, Barthelemy N, Bertz H, Bozzetti F, et al. ESPEN guidelines on nutrition in cancer patients. *Clin Nutr* 2017;36:11–48.
- [16] Wengler A, Micklewright A, Hébuterne X, Bozzetti F, Pertkiewicz M, Moreno J, et al. Monitoring of patients on home parenteral nutrition (HPN) in Europe: a questionnaire based study on monitoring practice in 42 centres. *Clin Nutr* 2006;25:693–700.
- [17] Pironi L, Steiger E, Brandt C, Joly F, Wanten G, Chambrier C, et al. Home parenteral nutrition provision modalities for chronic intestinal failure in adult patients: an international survey. *Clin Nutr* 2020;39:585–91.
- [18] Bischoff SC, Singer P, Koller M, Barazzoni R, Cederholm T, van Gossum A. Standard operation procedures for ESPEN guidelines and consensus papers. *Clin Nutr* 2015;34:1043–51.
- [19] Scottish Intercollegiate Guidelines Network (SIGN). SIGN 50: a guideline developer's handbook. Revised version. Edinburgh: SIGN; 2014.
- [20] German Association of the Scientific Medical Societies (AWMF). Standing Guidelines Commission. AWMF Guidance Manual and Rules for Guideline Development. 1st Edition 2012. English.
- [21] Pironi L, Konrad D, Brandt C, Joly F, Wanten G, Agostini F, et al. Clinical classification of adult patients with chronic intestinal failure due to benign disease: an international multicenter cross-sectional survey. *Clin Nutr* 2018;37:728–38.
- [22] Pironi L, Goulet O, Buchman A, Messing B, Gabe S, Candusso M, et al. Outcome on home parenteral nutrition for benign intestinal failure: a review of the literature and benchmarking with the European prospective survey of ESPEN. *Clin Nutr* 2012;31:831–45.
- [23] Amiot A, Messing B, Corcos O, Panis Y, Joly F. Determinants of home parenteral nutrition dependence and survival of 268 patients with non-malignant short bowel syndrome. *Clin Nutr* 2013;32:368–74.
- [24] Higuera I, Garcia-Peris P, Cambor M, Bretón I, Velasco C, Romero R, et al. Outcomes of a general hospital-based home parenteral nutrition (HPN) program; report of our experience from a 26-year period. *Nutr Hosp* 2014;30:359–65.
- [25] Dibb M, Soop M, Teubner A, Shaffer J, Abraham A, Carlson G, et al. Survival and nutritional dependence on home parenteral nutrition: three decades of experience from a single referral centre. *Clin Nutr* 2017;36:570–6.
- [26] Brandt CF, Hvistendahl M, Naimi RM, Tribler S, Staun M, Brøbech P, et al. Home parenteral nutrition in adult patients with chronic intestinal failure: the evolution over 4 decades in a tertiary referral center. *J Parenter Enter Nutr* 2017;41:1178–87.
- [27] Wu G, Jiang Y, Zhu X, Jin D, Han Y, Han J, et al. Prevalence and risk factors for complications in adult patients with short bowel syndrome receiving long-term home parenteral nutrition. *Asia Pac J Clin Nutr* 2017;26:591–7.
- [28] Joly F, Baxter J, Staun M, Kelly DG, Hwa YL, Corcos O, et al. Five-year survival and causes of death in patients on home parenteral nutrition for severe chronic and benign intestinal failure. *Clin Nutr* 2018;37:1415–22.
- [29] Pironi L, Hébuterne X, Van Gossum A, Messing B, Lyszkowska M, Colomb V, et al. Candidates for intestinal transplantation: a multicenter survey in Europe. *Am J Gastroenterol* 2006;101:1633–43.
- [30] Pironi L, Forbes A, Joly F, Colomb V, Lyszkowska M, Van Gossum A, et al. Survival of patients identified as candidates for intestinal transplantation: a 3-year prospective follow-up. *Gastroenterology* 2008;135:61–71.
- [31] Pironi L, Joly F, Forbes A, Colomb V, Lyszkowska M, Baxter J, et al. Long-term follow-up of patients on home parenteral nutrition in Europe: implications for intestinal transplantation. *Gut* 2011;60:17–25.
- [32] Mercadante S, Casaccio A, Mangione S. Medical treatment for inoperable malignant bowel obstruction: a qualitative systematic review. *J Pain Symptom Manag* 2007;33:217–23.
- [33] Bozzetti F, Amadori D, Bruera E, Cozzaglio L, Corli O, Filiberti A, et al. Guidelines on artificial nutrition versus hydration in terminal cancer patients. European Association for Palliative Care. *Nutrition* 1996;12:163–71.
- [34] Bozzetti F, Arends J, Lundholm K, Micklewright A, Zurcher G, Muscaritoli M. Espen guidelines on parenteral nutrition: non-surgical oncology. *Clin Nutr* 2009;28:445–54.
- [35] August DA, Huhmann MB. A.S.P.E.N. Clinical guidelines: nutrition support therapy during adult anticancer treatment and in hematopoietic cell transplantation. *J Parenter Enter Nutr* 2009;33:472–500.
- [36] Naghibi M, Smith TR, Elia M. A systematic review with meta-analysis of survival, quality of life and cost-effectiveness of home parenteral nutrition in patients with inoperable malignant bowel obstruction. *Clin Nutr* 2015;34:825–37.
- [37] Bozzetti F, Santarpia L, Pironi L, Thul P, Klek S, Gavazzi C, et al. The prognosis of incurable cachectic cancer patients on home parenteral nutrition: a multicentre observational study with prospective follow-up of 414 patients. *Ann Oncol* 2014;25:487–93.
- [38] Bozzetti F, Cotogni P, Lo Vullo S, Pironi L, Giardiello D, Mariani L. Development and validation of a nomogram to predict survival in incurable cachectic cancer patients on home parenteral nutrition. *Ann Oncol* 2015;26:2335–40.
- [39] Sowerbutts AM, Lal S, Sremanakova J, Clamp A, Todd C, Jayson GC, et al. Home parenteral nutrition for people with inoperable malignant bowel obstruction. *Cochrane Database Syst Rev* 2018;8:CD012812.
- [40] Bozzetti F, Forbes A. The ESPEN clinical practice Guidelines on Parenteral Nutrition: present status and perspectives for future research. *Clin Nutr* 2009;28:359–64.
- [41] Finocchiaro C, Gervasio S, Agnello E, Appiano S, Bertetto O, Ciuffreda L, et al. Multicentric study on home parenteral nutrition in advanced cancer patients. *Riv Ital Nutr Parenter Enterale* 2002;20:98–107.
- [42] Seys P, Tadmouri A, Senesse P, Radji A, Rotarski M, Balian A, et al. Home parenteral nutrition in elderly patients with cancer: an observational prospective study. *Bull Cancer* 2014;101:243–9.
- [43] Culine S, Chambrier C, Tadmouri A, Senesse P, Seys P, Radji A, et al. Home parenteral nutrition improves quality of life and nutritional status in patients with cancer: a French observational multicentre study. *Support Care Cancer* 2014;22:1867–74.
- [44] Vashi PG, Dahlk S, Popiel B, Lammersfeld CA, Ireton-Jones C, Gupta D. A longitudinal study investigating quality of life and nutritional outcomes in advanced cancer patients receiving home parenteral nutrition. *BMC Cancer* 2014;14:593.
- [45] Girke J, Seipt C, Markowski A, Luettig B, Schettler A, Momma M, et al. Quality of life and nutrition condition of patients improve under home parenteral nutrition: an exploratory study. *Nutr Clin Pract* 2016;31:659–65.
- [46] Cotogni P, De Carli L, Passera R, Amerio ML, Agnello E, Fadda M, et al. Longitudinal study of quality of life in advanced cancer patients on home parenteral nutrition. *Cancer Med* 2017;6:1799–806.

- [47] Hyltander A, Drott C, Unsgaard B, Tölli J, Körner U, Arfvidsson B, et al. The effect on body composition and exercise performance of home parenteral nutrition when given as adjunct to chemotherapy of testicular carcinoma. *Eur J Clin Invest* 1991;21:413–20.
- [48] Lundholm K, Daneryd P, Bosaeus I, Körner U, Lindholm E. Palliative nutritional intervention in addition to cyclooxigenase and erythropoietin treatment for patients with malignant disease: effects on survival, metabolism and function. *Cancer* 2004;100:1967–77.
- [49] Lundholm K, Körner U, Gunnebo L, Sixt-Ammilon P, Fouladiun M, Daneryd P, et al. Insulin treatment in cancer cachexia: effects on survival, metabolism, and physical functioning. *Clin Canc Res* 2007;13:2699–706.
- [50] Obling SR, Wilson BV, Pfeiffer P, Kjeldsen J. Home parenteral nutrition increases fat free mass in patients with incurable gastrointestinal cancer. Results of a randomized controlled trial. *Clin Nutr* 2019;38:182–90.
- [51] Dreesen M, Foulon V, Hiele M, Vanhaecht K, De Pourcq L, Pironi L, et al. Quality of care for cancer patients on home parenteral nutrition: development of key interventions and outcome indicators using a two-round Delphi approach. *Support Care Canc* 2013;21:1373–81.
- [52] Wanden-Berghe Lozano C, Virgili Casas N, Ramos Boluda E, Cuerda Compés C, Moreno Villares JM, Pereira Cunill JL, et al. Home and ambulatory artificial nutrition (NADYA) group report –home parenteral nutrition in Spain, 2016. *Nutr Hosp* 2017;34:1497–501.
- [53] Winkler MF, DiMaria-Ghalili RA, Guenter P, Resnick HE, Robinson L, Lyman B, et al. Characteristics of a cohort of home parenteral nutrition patients at the time of enrollment in the sustain registry. *J Parenter Enter Nutr* 2016;40:1140–9.
- [54] Smith T, Naghibi M, Stratton R, White S, Zeraschi S, Hughes SJ, et al. Artificial nutrition support in the UK 2005 – 2015. Adult home parenteral nutrition & home intravenous fluids A report by the British artificial nutrition survey (BANS), a committee of BAPEN (the British association for parenteral and enteral nutrition). 2016. ISBN: 978-1-899467-08-4. Available from: <http://www.bapen.org.uk>.
- [55] Pironi L, Candusso M, Biondo A, Bosco A, Castaldi P, Contaldo F, et al. Prevalence of home artificial nutrition in Italy in 2005: a survey by the Italian society for parenteral and enteral nutrition (SINPE). *Clin Nutr* 2007;26:123–32.
- [56] Pironi L, Regional Coordinators of SINPE. Development of home artificial nutrition in Italy over a seven year period: 2005–2012. *BMC Nutrition* 2017;3:6.
- [57] Hortencio TDR, Arendt BM, Teterina A, Jeejeebhoy KN, Gramlich LM, Whittaker JS, et al. Changes in home parenteral nutrition practice based on the Canadian home parenteral nutrition patient registry. *J Parenter Enter Nutr* 2017;41:830–6.
- [58] Bischoff SC, Austin P, Boeykens K, Chourdakis M, Cuerda C, Jonkers-Schuitema C, et al. ESPEN guideline on home enteral nutrition. *Clin Nutr* 2020;39:5–22.
- [59] Burgos R, Bretón I, Cereda E, Desport JC, Dziewias R, Genton L, et al. ESPEN guideline clinical nutrition in neurology. *Clin Nutr* 2018;37:354–96.
- [60] Kirby DF, Corrigan ML, Hendrickson E, Emery DM. Overview of home parenteral nutrition: an update. *Nutr Clin Pract* 2017;32:739–52.
- [61] Hotta M, Araki M, Urano A, Ohwada R. Home parenteral nutrition therapy in seven patients with anorexia nervosa: the role and indications. *Intern Med* 2014;53:2695–9.
- [62] Kumpf VJ, Tillman EM. Home parenteral nutrition: safe transition from hospital to home. *Nutr Clin Pract* 2012;27:749–57.
- [63] Durfee SM, Adams SC, Arthur E, Corrigan ML, Hammond K, Kovacevich DS, et al. A.S.P.E.N. Standards for nutrition support: home and alternate site care. *Nutr Clin Pract* 2014;29:542–55.
- [64] Vashi PG, Virginkar N, Popiel B, Edwin P, Gupta D. Incidence of and factors associated with catheter-related bloodstream infection in patients with advanced solid tumors on home parenteral nutrition managed using a standardized catheter care protocol. *BMC Infect Dis* 2017;17:372.
- [65] Pichitchaipitak O, Kcumdee S, Apivanich S, Chotiprasitsakul D, Shantavasinkul PC. Predictive factors of catheter-related bloodstream infection in patients receiving home parenteral nutrition. *Nutrition* 2018;46:1–6.
- [66] Winkler M, Guenter P. Long-term home parenteral nutrition: it takes an interdisciplinary approach. *J Infusion Nurs* 2014;37:389–95.
- [67] Dibb M, Teubner A, Theis V, Shaffer J, Lal S. Review article: the management of long-term parenteral nutrition. *Aliment Pharmacol Ther* 2013;37:587–603.
- [68] Dibb M, Lal S. Home parenteral nutrition: vascular access and related complications. *Nutr Clin Pract* 2017;32:769–76.
- [69] Boeykens K, Van Hecke A. Advanced practice nursing: nutrition Nurse Specialist role and function. *Clin Nutr ESPEN* 2018;26:72–6.
- [70] Dreesen M, Foulon V, Vanhaecht K, De Pourcq L, Hiele M, Willems L. Identifying patient-centered quality indicators for the care of adult home parenteral nutrition (HPN) patients. *J Parenter Enter Nutr* 2014;38:840–6.
- [71] Dreesen M, Foulon V, Vanhaecht K, Hiele M, De Pourcq L, Pironi L, et al. Development of quality of care interventions for adult patients on home parenteral nutrition (HPN) with a benign underlying disease using a two-round Delphi approach. *Clin Nutr* 2013;32:59–64.
- [72] Storr J, Twyman A, Zingg W, Damani N, Kilpatrick C, Reilly J, et al. Core components for effective infection prevention and control programmes: new WHO evidence-based recommendations. *Antimicrob Resist Infect Contr* 2017;6:6.
- [73] O'Grady NP, Alexander M, Burns LA, Dellinger EP, Garland J, Heard SO, et al. Guidelines for the prevention of intravascular catheter-related infections. *Clin Infect Dis* 2011;52:e162–93.
- [74] Boeykens K. Monitoring patients on home parenteral nutrition. In: Bozzetti F, Staun M, Van Gossom A, editors. Home parenteral nutrition 2nd edition, vols. 318–324. CABInternational; 2015. ISBN 978-1-78064-311-3.
- [75] Bond A, Teubner A, Taylor M, Cawley C, Abraham A, Dibb M, et al. Assessing the impact of quality improvement measures on catheter related blood stream infections and catheter salvage: experience from a national intestinal failure unit. *Clin Nutr* 2018;37:2097–101.
- [76] Schneider PJ. Nutrition support teams: an evidence-based practice. *Nutr Clin Pract* 2006;21:62–7.
- [77] Carreira Villamor JM, Reyes Perez R, Pulido-Duque JM, Gorrioz Gomez E, Pardo MD, Argiles Vives JM, et al. Percutaneous implant of Hickman catheters and reservoirs. Long-term experience. *Rev Clin Esp* 1997;740–4.
- [78] Steiger E. Obtaining and maintaining vascular access in the home parenteral nutrition patient. *J Parenter Enter Nutr* 2002;26:517–30.
- [79] Kuizon D, Gordon SM, Dolmatch BL. Single-lumen subcutaneous ports inserted by interventional radiologists in patients undergoing chemotherapy: incidence of infection and outcome of attempted catheter salvage. *Arch Intern Med* 2001;161:406–10.
- [80] Raman M, Gramlich L, Whittaker S, Allard JP. Canadian home total parenteral nutrition registry: preliminary data on the patient population. *Can J Gastroenterol* 2007;21:643–8.
- [81] Verso M, Agnelli G, Kamphuisen PW, Ageno W, Bazzano M, Lazzaro A, et al. Risk factors for upper limb deep vein thrombosis associated with the use of central vein catheter in cancer patients. *Intern Emerg Med* 2008;3:117–22.
- [82] Petersen J, Delaney JH, Brakstad MT, Rowbotham RK, Bagley Jr CM. Silicone venous access devices positioned with their tips high in the superior vena cava are more likely to malfunction. *Am J Surg* 1999;178:38–41.
- [83] Cadman A, Lawrance JA, Fitzsimmons L, Spencer-Shaw A, Swindell R. To clot or not to clot? that is the question in central venous catheters. *Clin Radiol* 2004;59:349–55.
- [84] Kovacevich DS, Corrigan M, Ross VM, McKeever L, Hall AM, Braunschweig C. American society for parenteral and enteral nutrition guidelines for the selection and care of central venous access devices for adult home parenteral nutrition administration. *J Parenter Enter Nutr* 2019;43:15–31.
- [85] Santacruz E, Mateo-Lobo R, Riveiro J, Nattero L, Vega-Piñero B, Lomba G, et al. Infectious complications in home parenteral nutrition: a long-term study with peripherally inserted central catheters, tunneled catheters, and ports. *Nutrition* 2019;58:89–93.
- [86] Santacruz-Cerdán E, Arcano K, Arrieta Blanco F, Ortiz Flores A, Mateo Lobo R, Botella Carretero JL, et al. Effectiveness of long-term home parenteral nutrition with peripherally inserted central catheter: a case report. *Nutr Hosp* 2016;33:185–7.
- [87] Christensen LD, Holst M, Bech LF, Drustrup L, Nygaard L, Skallerup A, et al. Comparison of complications associated with peripherally inserted central catheters and Hickman™ catheters in patients with intestinal failure receiving home parenteral nutrition. Six-year follow up study. *Clin Nutr* 2016;35:912–7.
- [88] Cotogni P, Barbero C, Garrino C, Degiorgis C, Mussa B, De Francesco A, et al. Peripherally inserted central catheters in non-hospitalized cancer patients: 5-year results of a prospective study. *Support Care Canc* 2015;23:403–9.
- [89] Touré A, Duchamp A, Peraldi C, Barnoud D, Lauverjat M, Gelas P, et al. Comparative study of peripherally-inserted and Broviac catheter complications in home parenteral nutrition patients. *Clin Nutr* 2015;34:49–52.
- [90] Bech LF, Drustrup L, Nygaard L, Skallerup A, Christensen LD, Vinter-Jensen L, et al. Environmental risk factors for developing catheter-related bloodstream infection in home parenteral nutrition patients: a 6-year follow-up study. *J Parenter Enter Nutr* 2016;40:989–94.
- [91] Ross VM, Guenter P, Corrigan ML, Kovacevich D, Winkler MF, Resnick HE, et al. Central venous catheter infections in home parenteral nutrition patients: outcomes from sustain: American society for parenteral and enteral nutrition's national patient registry for nutrition care. *Am J Infect Contr* 2016;44:1462–8.
- [92] Opilla M. Peripherally inserted central catheter experience in long-term home parenteral nutrition patients. *Java* 2017;22:42–5.
- [93] Hon K, Bihari S, Holt A, Bersten A, Kulkarni H. Rate of catheter-related bloodstream infections between tunneled central venous catheters versus peripherally inserted central catheters in adult home parenteral nutrition: a meta-analysis. *J Parenter Enter Nutr* 2019;43:41–53.
- [94] Hurt RT, Steiger E. Early history of home parenteral nutrition: from hospital to home. *Nutr Clin Pract* 2018;33:598–613.
- [95] <https://www.fda.gov/medicaldevices/productsandmedicalprocedures/generalhospitaldevicesandsupplies/infusionpumps/>
- [96] Ayers P, Adams S, Boullata J, Gervasio J, Holcombe B, Kraft MD, et al. A.S.P.E.N. parenteral nutrition safety consensus recommendations: translation into practice. *Nutr Clin Pract* 2014;29:277–82.
- [97] Mirtallo J, Canada T, Johnson D, Kumpf V, Petersen C, Sacks G, et al. Safe practices for parenteral nutrition. *J Parenter Enter Nutr* 2004;28:539–70.
- [98] Auty B. The DHSS evaluation programme for infusion control instruments. *Eng Med* 1986;15:175–83.

- [99] Saqui O, Fernandes Gail, Allard JP. Quality of life analysis during transition from stationary to portable infusion pump in home parenteral nutrition patients: a Canadian experience. *Nutr Clin Pract* 2014;29:131–41.
- [100] Boutin J, Hagan E. Patients' preference regarding portable pumps. *J Intraven Nurs* 1992;15:230–2.
- [101] Ullman AJ, Cooke ML, Mitchell M, Lin F, New K, Long DA, et al. Dressing and securement for central venous access devices (CVADs): a Cochrane systematic review. *Int J Nurs Stud* 2016;59:177–96.
- [102] Gillies D, O'Riordan E, Carr D, O'Brien I, Frost J, Gunning R. Central venous catheter dressings: a systematic review. *J Adv Nurs* 2003;44:623–32.
- [103] Hoffmann KK, Weber DJ, Samsa GP, Rutala WA. Transparent polyurethane film as an intravenous catheter dressing. A meta-analysis of the infection risks. *J Am Med Assoc* 1992;267:2072–6.
- [104] Laura R, Degl'Innocenti M, Mocali M, Alberani F, Boschi S, Giraudi A, et al. Comparison of two different time interval protocols for central venous catheter dressing in bone marrow transplant patients: results of a randomized, multicenter study. *Haematol* 2000;85:275–9. The Italian Nurse Bone Marrow Transplant Group (GITMO).
- [105] Gavin NC, Webster J, Chan RJ, Rickard CM. Frequency of dressing changes for central venous access devices on catheter-related infections. *Cochrane Database Syst Rev* 2016;2:CD009213.
- [106] Kolacek S, Puntis JW, Hojsak I. ESPGHAN/ESPEN/ESPR/CSPEN guidelines on pediatric parenteral nutrition: venous access. *Clin Nutr* 2018;37:2379–91.
- [107] Olson K, Rennie RP, Hanson J, Ryan M, Gilpin J, Falsetti M, et al. Evaluation of a no-dressing intervention for tunneled central venous catheter exit sites. *J Infusion Nurs* 2004;27:37–44.
- [108] Austin PD, Hand KS, Elia M. Systematic review and meta-analyses of the effect of lipid emulsion on microbial growth in parenteral nutrition. *J Hosp Infect* 2016;94:307–19.
- [109] Raad I, Hanna HA, Awad A, Alrahwan A, Bivins C, Khan A, et al. Optimal frequency of changing intravenous administration sets: is it safe to prolong use beyond 72 hours? *Infect Control Hosp Epidemiol* 2001;22:136–9.
- [110] Sitges-Serra A, Liñares J, Pérez JL, Jaurrieta E, Lorente L. A randomized trial on the effect of tubing changes on hub contamination and catheter sepsis during parenteral nutrition. *J Parenter Enter Nutr* 1985;9:322–5.
- [111] Ullman AJ, Cooke ML, Gillies D, Marsh NM, Daud A, McGrail MR, et al. Optimal timing for intravascular administration set replacement. *Cochrane Database Syst Rev* 2013;CD003588.
- [112] Gillies D, O'Riordan L, Wallen M, Rankin K, Morrison A, Nagy S. Timing of intravenous administration set changes: a systematic review. *Infect Control Hosp Epidemiol* 2004;29:5240–50.
- [113] Gavin NC, Button E, Keogh S, McMillan D, Rickard C. Does parenteral nutrition increase the risk of catheter-related bloodstream infection? A systematic literature review. *J Parenter Enter Nutr* 2017;41:918–28.
- [114] Santarpia L, Buonomo A, Pagano MC, Alfonsi L, Foggia M, Mottola M, et al. Central venous catheter related bloodstream infections in adult patients on home parenteral nutrition: prevalence, predictive factors, therapeutic outcome. *Clin Nutr* 2016;35:1394–8.
- [115] Edakkambath Varayil J, Whitaker JA, Okano A, Carnell JJ, Davidson JB, Enzler MJ, et al. Catheter salvage after catheter-related bloodstream infection during home parenteral nutrition. *J Parenter Enter Nutr* 2017;41:481–8.
- [116] Cotogni P, Pittiruti M, Barbero C, Monge T, Palmo A, Boggio Bertinet D. Catheter-related complications in cancer patients on home parenteral nutrition: a prospective study of over 51,000 catheter days. *J Parenter Enter Nutr* 2013;37:375–83.
- [117] Dreesen M, Foulon V, Spriet I, Goossens GA, Hiele M, De Pourcq L, et al. Epidemiology of catheter-related infections in adult patients receiving home parenteral nutrition: a systematic review. *Clin Nutr* 2013;32:16–26.
- [118] Brewer JD, Gonzalez AB, Baum CL, Arpey CJ, Roenigk RK, Otley CC, et al. Comparison of sterile vs nonsterile gloves in cutaneous surgery and common outpatient dental procedures: a systematic review and meta-analysis. *JAMA Dermatol* 2016;152:1008–14.
- [119] Heal C, Sriharan S, Buttner PG, Kimber D. Comparing non-sterile to sterile gloves for minor surgery: a prospective randomised controlled non-inferiority trial. *Med J Aust* 2015;202:27–31.
- [120] Chaiyakunapruk N, Veenstra DL, Lipsky BA, Saint S. Chlorhexidine compared with povidone-iodine solution for vascular catheter-site care: a meta-analysis. *Ann Intern Med* 2002;136:792–801.
- [121] Mimoz O, Lucet JC, Kerforme T, Pascal J, Souweine B, Goudet V, et al. Skin antisepsis with chlorhexidine-alcohol versus povidone iodine-alcohol, with and without skin scrubbing, for prevention of intravascular-catheter-related infection (CLEAN): an open-label, multicentre, randomised, controlled, two-by-two factorial trial. *Lancet* 2015;386:2069–77.
- [122] Lai NM, Lai NA, O'Riordan E, Chaiyakunapruk N, Taylor JE, Tan K. Skin antisepsis for reducing central venous catheter-related infections. *Cochrane Database Syst Rev* 2016;CD010140.
- [123] Darouiche RO, Wall Jr MJ, Itani KM, Otterson MF, Webb AL, Carrick MM, et al. Chlorhexidine-alcohol versus povidone-iodine for surgical-site antisepsis. *N Engl J Med* 2010;362:18–26.
- [124] Yasuda H, Sanui M, Abe T, Shime N, Komuro T, Hatakeyama J, et al. Comparison of the efficacy of three topical antiseptic solutions for the prevention of catheter colonization: a multicenter randomized controlled study. *Crit Care* 2017;21:32.
- [125] Blot K, Bergs J, Vogelers D, Blot S, Vandijck D. Prevention of central line-associated bloodstream infections through quality improvement interventions: a systematic review and meta-analysis. *Clin Infect Dis* 2014;59:96–105.
- [126] National Institute for Health and Clinical Excellence. Infection: prevention and control of healthcare-associated infections in primary and community care: partial update of NICE clinical guideline 2. National clinical guideline centre (UK). London: Royal College of Physicians (UK); 2012.
- [127] Picheansathian W. A systematic review on the effectiveness of alcohol-based solutions for hand hygiene. *Int J Nurs Pract* 2004;10:3–9.
- [128] Girou E, Loyeau S, Legrand P, Oppein F, Brun-Buisson C. Efficacy of hand rubbing with alcohol based solution versus standard handwashing with antiseptic soap: randomised clinical trial. *BMJ* 2002;325:362.
- [129] Kac G, Podglajen I, Gueneret M, Vaupré S, Bissery A, Meyer G. Microbiological evaluation of two hand hygiene procedures achieved by healthcare workers during routine patient care: a randomized study. *J Hosp Infect* 2006;60:32–9.
- [130] Casey AL, Burnell S, Whinn H, Worthington T, Faroqui MH, Elliott TS. A prospective clinical trial to evaluate the microbial barrier of a needleless connector. *J Hosp Infect* 2007;65:212–8.
- [131] Yébenes JC, Vidaur L, Serra-Prat M, Sirvent JM, Batlle J, Motje M, et al. Prevention of catheter-related bloodstream infection in critically ill patients using a disinfectable, needle-free connector: a randomized controlled trial. *Am J Infect Contr* 2004;32:291–5.
- [132] Casey AL, Worthington T, Lambert PA, Quinn D, Faroqui MH, Elliott TS. A randomized, prospective clinical trial to assess the potential infection risk associated with the PosiFlow needleless connector. *J Hosp Infect* 2003;54:288–93.
- [133] Btaiche IF, Kovacevich DS, Khalidi N, Papke LF. The effects of needleless connectors on catheter-related bloodstream infections. *Am J Infect Contr* 2011;39:277–83.
- [134] Williams A. Catheter occlusion in home infusion: the influence of needleless connector design on central catheter occlusion. *J Infusion Nurs* 2018;41:52–7.
- [135] Ling ML, Apisarnthanarak A, Jaggi N, Harrington G, Morikane K, Thu le TA, et al. APSIC guide for prevention of central line associated bloodstream infections (CLABSI). *Antimicrob Resist Infect Contr* 2016;5:16.
- [136] Moureau NL, Flynn J. Disinfection of needleless connector hubs: clinical evidence systematic review. *Nurs Res Pract* 2015;2015:796762.
- [137] Breimer L, Geijer H, Berggren L. Disinfection of injection ports - a systematic overview of optimal scrub-time. *Lakartidningen* 2018;115.
- [138] Menyhay SZ, Maki DG. Disinfection of needleless catheter connectors and access ports with alcohol may not prevent microbial entry: the promise of a novel antiseptic-barrier cap. *Infect Control Hosp Epidemiol* 2006;27:23–7.
- [139] Voor In 't Holt AF, Helder OK, Vos MC, Schafthuisen L, Stülz S, van den Hoogen A, et al. Antiseptic barrier cap effective in reducing central line-associated bloodstream infections: a systematic review and meta-analysis. *Int J Nurs Stud* 2017;69:34–40.
- [140] Chang L, Tsai JS, Huang SJ, Shih CC. Evaluation of infectious complications of the implantable venous access system in a general oncologic population. *Am J Infect Contr* 2003;31:34–9.
- [141] Karamanoglu A, Yumuk PF, Gumus M, Ekenel M, Aliustaoglu M, Selimen D, et al. Port needles: do they need to be removed as frequently in infusional chemotherapy? *J Infusion Nurs* 2003;26:239–42.
- [142] Robbins J, Cromwell P, Korones DN. Swimming and central venous catheter-related infections in the child with cancer. *J Pediatr Oncol Nurs* 1999;16:51–6.
- [143] Miller J, Dalton MK, Duggan C, Lam S, Iglesias J, Jaksic T, et al. Going with the flow or swimming against the tide: should children with central venous catheters swim? *Nutr Clin Pract* 2014;29:97–109.
- [144] Ivy DD, Calderbank M, Wagner BD, Dolan S, Nyquist AC, Wade M, et al. Closed-hub systems with protected connections and the reduction of risk of catheter-related bloodstream infection in pediatric patients receiving intravenous prostanoid therapy for pulmonary hypertension. *Infect Control Hosp Epidemiol* 2009;30:823–9.
- [145] Brito ARO, Nishinari K, Saad PF, Saad KR, Pereira MAT, Emídio SCD, et al. Comparison between saline solution containing heparin versus saline solution in the lock of totally implantable catheters. *Ann Vasc Surg* 2018;47:85–9.
- [146] Dal Molin A, Clerico M, Baccini M, Guerretta L, Sartorello B, Rasero L. Normal saline versus heparin solution to lock totally implanted venous access devices: results from a multicenter randomized trial. *Eur J Oncol Nurs* 2015;19:638–43.
- [147] Dal Molin A, Allara E, Montani D, Milani S, Frassati C, Cossu S, et al. Flushing the central venous catheter: is heparin necessary? *J Vasc Access* 2014;15:241–8.
- [148] Pittiruti M, Bertoglio S, Scoppettuolo G, Biffi R, Lamperti M, Dal Molin A, et al. Evidence-based criteria for the choice and the clinical use of the most appropriate lock solutions for central venous catheters (excluding dialysis catheters): a GAVECeLT consensus. *J Vasc Access* 2016;17:453–64.
- [149] Shanks RM, Donegan NP, Graber ML, Buckingham SE, Zegans ME, Cheung AL, et al. Heparin stimulates *Staphylococcus aureus* biofilm formation. *Infect Immun* 2005;73:4596–606.
- [150] Allon M. Prophylaxis against dialysis catheter-related bacteremia: a glimmer of hope. *Am J Kidney Dis* 2008;51:165–8.
- [151] Tribler S, Brandt CF, Petersen AH, Petersen JH, Fuglsang KA, Staun M, et al. Taurolidine-citrate-heparin lock reduces catheter-related bloodstream



- infections in intestinal failure patients dependent on home parenteral support: a randomized, placebo-controlled trial. *Am J Clin Nutr* 2017;106:839–48.
- [152] Wouters Y, Theilla M, Singer P, Tribler S, Jeppesen PB, Pironi L, et al. Randomised clinical trial: 2% taurolidine versus 0.9% saline locking in patients on home parenteral nutrition. *Aliment Pharmacol Ther* 2018;48:410–22.
- [153] Wouters Y, Roosenboom B, Causevic E, Kievit W, Groenewoud H, Wanten GJA. Clinical outcomes of home parenteral nutrition patients using taurolidine as catheter lock: a long-term cohort study. *Clin Nutr* 2019;38:2210–8.
- [154] Zerla PA, Canelli A, Cerne L, Caravella G, Gilardini A, De Luca G, et al. Evaluating safety, efficacy, and cost-effectiveness of PICC securement by subcutaneously anchored stabilization device. *J Vasc Access* 2017;18:238–42.
- [155] Macmillan T, Pennington M, Summers JA, Goddard K, Zala D, Herz N, et al. SecurAchat for securing peripherally inserted central catheters: a NICE medical technology guidance. *Appl Health Econ Health Pol* 2018;16:779–91.
- [156] Goossens GA, Grumiaux N, Janssens C, Jérôme M, Fieus S, Moons P, et al. SecurAstaP trial: securement with SecurAcath versus StatLock for peripherally inserted central catheters, a randomised open trial. *BMJ Open* 2018;8:e016058.
- [157] Elen Hughes M. Reducing PICC migrations and improving patient outcomes. *Br J Nurs* 2014;23(12):14–8.
- [158] Gavin NC, Button E, Castillo MI, Ray-Barruel G, Keogh S, McMillan DJ, et al. Does a dedicated lumen for parenteral nutrition administration reduce the risk of catheter-related bloodstream infections? A systematic literature review. *J Infusion Nurs* 2018;41:122–30.
- [159] Buchman AL, Opilla M, Kwasy M, Diamantidis TG, Okamoto R. Risk factors for the development of catheter-related bloodstream infections in patients receiving home parenteral nutrition. *J Parenter Enter Nutr* 2014;38:744–9.
- [160] Munck A, Malbezin S, Bloch J, Gerardin M, Lebougeois M, Derelle J, et al. Follow-up of 452 totally implantable vascular devices in cystic fibrosis patients. *Eur Respir J* 2004;23:430–4.
- [161] Boullata J, Gilbert K, Sacks G, Labossiere R, Crill C, Goday P, et al. ASPEN clinical guidelines: parenteral nutrition ordering, order review, compounding, labeling and dispensing. *J Parenter Enter Nutr* 2014;38:334–77.
- [162] Mühlebach S, Franken C, Stanga Z. Practical handling of AIO admixtures – guidelines on parenteral nutrition, chapter 10. *Ger Med Sci* 2009;7:Doc18.
- [163] Pietka M, Szczepanek K, Szybinski P, Klek S. Ready-to-use (RTU) bags versus compounded parenteral nutrition: battle for microbiological safety. *Clin Nutr* 2013;32:199–200.
- [164] Yu J, Wu G, Tang Y, Ye Y, Zhang Z. Efficacy, safety, and preparation of standardized parenteral nutrition regimens: three-chamber bags vs compounded monobags – a prospective, multicenter, randomized, single-blind clinical trial. *Nutr Clin Pract* 2017;32:545–51.
- [165] Hall JW. Safety, cost, and clinical considerations for the use of premixed parenteral nutrition. *Nutr Clin Pract* 2015;30:325–30.
- [166] Berlanda D, Sabin P, Gimeno-Ballester V, Romero-Jimenez R, Zapata-Rojas A, Marquez E, et al. Cost analysis of adult parenteral nutrition systems: three-compartment bag versus customized. *Nutr Hosp* 2013;28:2135–41.
- [167] Turpin RS, Canada T, Liu FX, Mercaldi CJ, Pontes-Arruda A, Wischmeyer P. Nutrition therapy cost analysis in the US: pre-mixed multi-chamber bag vs compounded parenteral nutrition. *Appl Health Econ Health Pol* 2011;9:281–92.
- [168] Pichard C, Schwarz G, Frei A, Kyle U, Joliet P, Morel P, et al. Economic investigation of the use of three-compartment total parenteral nutrition bag: prospective randomized unblinded controlled study. *Clin Nutr* 2000;19:245–51.
- [169] Turpin RS, Solem C, Pontes-Arruda A, Sanon M, Mehta S, Xiaoqing Liu F, et al. The impact of parenteral nutrition preparation on bloodstream infection risk and costs. *Eur J Clin Nutr* 2014;68:953–8.
- [170] Liu FX, Turpin R, Mercaldi K, Reynolds MW. Methods to identify and compare bloodstream infection rates among patients administered parenteral nutrition via hospital compounded vs. premixed multi-chamber bags. *Value Health* 2010;13(3).
- [171] Beattie C, Allard J, Raman M. Comparison between premixed and compounded parenteral nutrition solutions in hospitalized patients requiring parenteral nutrition. *Nutr Clin Pract* 2016;31:229–34.
- [172] Milicevic L, Kernan W, Ukleja A. Standardized two-compartment parenteral nutrition utilization at a tertiary referral hospital. *Clin Nutr Suppl* 2012;7:127–8.
- [173] Alfonso JE, Berlanda D, Ukleja A, Boullata J. Clinical, ergonomic, and economic outcomes with multichamber bags compared with (hospital) pharmacy compounded bags and multibottle systems: a systematic literature review. *J Parenter Enter Nutr* 2017;41:1162–77.
- [174] Aeberhard C, Steuer C, Saxer C, Huber A, Stanga Z, Mühlebach S. Physicochemical stability and compatibility testing of Leviracetam in all-in-one parenteral admixture in daily practice. *Eur J Pharmaceut Sci* 2017;96:449–55.
- [175] Mühlebach S, et al. Pharmaceutical aspects of parenteral nutrition support, chap. 6.2.3.2. (How to prepare PN admixtures, role and function of the pharmacist); chap. 6.2.3.3. Stability and compatibility on PN admixtures, Chap 6.2.3.4 Drugs and nutritional admixtures. In: Sobotka L, et al., editors. *Basics of clinical nutrition*. Galén (ESPEN) Prague. 5th ed.; 2018 [in print].
- [176] Aeberhard C, Mühlebach S. Parenterale Ernährung – Grundlagen und Durchführung (CME). *Parenteral nutrition – basics and Good Practice*. Aktuelle Ernährungsmed 2017;42:53–76.
- [177] White R. The Pennington Lecture Quality parenteral nutrition: an ideal mixed bag. *Proc Nutr Soc* 2011;70:285–92.
- [178] Kochevar M, Guenter P, Holcombe B, Malone A, Mirtallo J. ASPEN statement on parenteral nutrition standardization. *J Parenter Enter Nutr* 2007;31:441–8.
- [179] Mühlebach S. Parenteral nutrition. Reference module in food science, encyclopedia of food security and sustainability. 1st ed., vol. 2. imprint Elsevier US; 2019, ISBN 9780128126875. p. 131–42. published 28th November 2018. eBook ISBN: 9780128126882.
- [180] Ayers P, Adams S, Boullata J, Gervasio J, Holcombe B, Kraft MD, et al. A.S.P.E.N. parenteral nutrition safety consensus recommendations. *J Parenter Enter Nutr* 2014;38:296–333.
- [181] Pietka M, Watrobska-Swiatlikowska D, Szczepanek K, Szybinski P, Sznitowska M, Kłek S. Nutrition Support Teams: the cooperation among physicians and pharmacists helps improve cost-effectiveness on HPN. *Nutr Hosp* 2015;31:251–9.
- [182] Lauverjat M, Hadj Aissa A, Vanhems P, Boulétreau P, Fouque D, Chambrier C. Chronic dehydration may impair renal function in patients with chronic intestinal failure on long-term parenteral nutrition. *Clin Nutr* 2006;25:75–81.
- [183] Konrad D, Roberts S, Corrigan ML, Hamilton C, Steiger E, Kirby DF. Treating dehydration at home avoids healthcare costs associated with emergency department visits and hospital readmissions for adult patients receiving home parenteral support. *Nutr Clin Pract* 2017;32:385–91.
- [184] Dreesen M, Pironi L, Wanten G, Szczepanek K, Foulon V, Willems L, et al. Outcome indicators for home parenteral nutrition care: point of view from adult patients with benign disease. *J Parenter Enter Nutr* 2015;39:828–36.
- [185] Messing B, Lemann M, Landais P, Gouttebel MC, Gerard-Boncompain M, Saudin F, et al. Prognosis of patients with nonmalignant chronic intestinal failure receiving long-term home parenteral nutrition. *Gastroenterology* 1995;108:1005–10.
- [186] Bischoff SC, Kester L, Meier R, Radziwill R, Schwab D, Thul P. Organisation, regulations, preparation and logistics of parenteral nutrition in hospitals and homes; the role of the nutrition support team – guidelines on Parenteral Nutrition Chapter 8. *Ger Med Sci* 2009;7:Doc20.
- [187] Huisman-de Waal G, Versleijen M, van Achterberg T, Jansen JB, Sauerwein H, Schoonhoven L, et al. Psychosocial complaints are associated with venous access-device related complications in patients on home parenteral nutrition. *J Parenter Enter Nutr* 2011;35:588–95.
- [188] Huisman-de Waal G, van Achterberg T, Jansen J, Wanten G, Schoonhoven L. High-tech home care: overview of professional care in patients on home parenteral nutrition and implications for nursing care. *J Clin Nurs* 2011;20:2125–34.
- [189] Park JY. Implementing a central venous catheter self-management education program for patients with cancer. *Eur J Oncol Nurs* 2016;25:1–8.
- [190] Hudgins JD, Goldberg GV, Fell GL, Puder M, Eisenberg MA. Reducing time to antibiotics in children with intestinal failure, central venous line and fever. *Pediatrics* 2017;140.
- [191] Chaftari P, Chaftari AM, Adachi J, Hachem R, Raad S, Natividad E. Improvement in the diagnosis of catheter-related bloodstream infections in a tertiary cancer center. *Am J Infect Contr* 2017;45:e34–9.
- [192] Pironi L, Baxter JP, Lauro A, Guidetti M, Agostini F, Zanfi C, et al. Assessment of quality of life on home parenteral nutrition and after intestinal transplantation using treatment-specific questionnaires. *Am J Transplant* 2012;12(Suppl 4):60–6.
- [193] Baxter JP, Fayers PM, Bozzetti F, Kelly D, Joly F, Wanten G, et al. An international study of the quality of life of adult patients treated with home parenteral nutrition. *Clin Nutr* 2019;38:1788–96.
- [194] Mantegazza C, La Vela V, Hill S, Köglmeier J. Travelling with children on home parenteral nutrition. *J Pediatr Gastroenterol Nutr* 2016;62:145–9.
- [195] Donabedian A. Evaluating the quality of medical care. *Milbank Q* 2005;83:691–729.