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Conference on 'Malnutrition matters'

The Pennington Lecture
Quality parenteral nutrition: an ideal mixed bag

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Professor Pennington was an advocate for quality in all aspects of nutrition support and its delivery, ensuring that the patient remained at the centre of all decisions, and that specialist artificial nutrition support was best managed by the multidisciplinary nutrition team and the education of the wider healthcare community. Within the conference theme of 'Quality', this commentary aims to outline drivers for and risks to aspects of quality in parenteral nutrition (PN) services. Quality is defined as a particular property or attribute associated with excellence; in the context of the provision of PN this can be translated to quality processes and standards in the assessment, prescription, preparation, administration and monitoring of PN. Quality products and services are delivered through the timely application of knowledge, competence, procedures and standards. Quality can be so easily compromised; inattention, ignorance and arrogance all play their part. PN is a high-risk therapy; the quality of its delivery should not be entirely dependent on the skills, knowledge and competence of those delivering this care but on accepted standards, procedures, communication, resource and infrastructure. Identification of key steps in the provision of PN and a review of the relevant patient safety data reveal points where safeguards can be put in place to ensure quality is not compromised. Full evaluation of standardisation, computerisation and competency-based training as risk-reduction strategies is required.

Quality: Parenteral nutrition: Risk: Competence

When deciding on the subject for this year's Pennington Lecture, I considered the conference theme of quality and what it meant to me as a pharmacist. In my years as a nutrition team pharmacist, aseptic services manager and non-medical prescriber, there have been many changes in the provision of parenteral nutrition (PN), both organisational and pharmaceutical. This commentary aims to outline drivers for, and risks to, quality within the context of a PN service and considers risk-reduction strategies that are commonly applied.

PN remains the most complex injectable formulation in clinical use, with over fifty individual components in a stable system; no other pharmaceutical comes close in terms of chemical and physical complexity. PN is considered a high-risk product due to the prescription, composition and monitoring requirements; in pharmaceutical terms it is also a high-cost product.

When PN was developed in the 1940s, it was a highly specialised therapy requiring expert management to minimise the severe complications that could develop. The early challenges of accurate determination of requirements and the provision of pharmaceutically and microbiologically stable individual nutrient solutions were overcome through the tireless research of dedicated specialists. In the last 20 years, the provision of PN has undergone a revolution through an increased awareness of it benefits in appropriate patients and the development of 'convenience' products. PN is now widely available to patients in all care settings; it is no longer restricted to specialist units that invested in the personnel and aseptic facilities necessary to provide these complex solutions.

Despite its widespread availability, PN remains an infrequently used therapy. Within the UK, PN is administered to approximately 20 000 patients per year[1]; this

Abbreviations: BAPEN, British Association for Parenteral and Enteral Nutrition; NHS, National Health Service; NCEPOD, National Confidential Enquiry into Patient Outcome and Death; NPSA, National Patient Safety Agency; NRLS, national reporting and learning system; PN, parenteral nutrition.

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represents less than 0·2% of hospital admissions. In comparison, this is less than one-fifteenth of the patients who receive chemotherapy each year.

The quality of care for patients requiring PN within secondary care has recently been called into question by a national audit undertaken by the National Confidential Enquiry into Patient Outcome and Death (NCEPOD). The report paints a bleak picture of the quality of care for patients receiving PN, both adults and children, with less than 25% receiving acceptable levels of care[1]. This report also identifies other areas where quality could be improved. Disappointingly, this report also demonstrates that many organisations are still failing to implement the guidance issued by the National Institute for Health and Clinical Excellence in 2006[2]; this should serve to galvanise organisations to relook at the provision of nutritional care. There is clearly a need to re-focus on the quality of care and services for patients requiring PN. The NCEPOD report puts in sharp focus aspects of PN care where there is considerable room for improvement and throws the gauntlet down to organisations such as the British Association for Parenteral and Enteral Nutrition (BAPEN) to raise awareness of the standards necessary for vulnerable patients dependent on this high-risk therapy.

We are entering another period of change within the National Health Service (NHS). 'Improving the quality of care will become the main purpose of the NHS' according to the latest Department of Health White Paper 'Equity and Excellence: Liberating the NHS'[3]. This applies pressure on the NHS to deliver cost-effective services without compromising quality, and is a powerful driver for change.

Quality assurance in parenteral nutrition provision

There are a number of clearly identifiable processes in the provision of PN. Each of these processes has to be considered and evaluated individually to determine how best to quality assure that process. However, much of service and product delivery is dependent on the decisions and actions of individuals.

There are many measures that have been tried to reduce the risks and improve the quality of PN provision. Understanding how and why mistakes happen is key. Within the context of PN solution provision, pharmacists and pharmacy staff have been striving to improve the quality of the solutions, their stability, suitability, their preparation and presentation. Standardisation and computer-aided prescribing as an approach to improving quality have had both their supporters and their critics, and will be discussed in more detail later.

Learning from our mistakes: an organisation with a memory

'To Err is Human' a report from the Institute of Medicine[4], issued in the United States in 1999, aimed to raise the profile of errors as a means of building a safer healthcare system. The sentiments of that report were echoed by the Department of Health white paper 'An organisation with a memory' published the following year[5]. Both reports described how medical errors were costly not only in terms of emotional costs to patients and families but also to the carers and professionals involved. The financial costs are not just those of litigation, but of additional medical and social care and loss of income. Both reports also emphasise on how an understanding of how and why errors occur is essential to build safeguards into all healthcare systems.

There has been widespread evaluation and implementation of Human Reliability Analysis in industry, particularly in aviation. The application of such error analysis techniques to potential risks in healthcare is rare. Although the inherent safety culture is likely to negatively impact on the use of Human Reliability Analysis techniques in healthcare, much is likely to be due to a lack of awareness of the usefulness of the techniques and their applicability to the problem of human error in the clinical context. Another significant barrier is the lack of validation of these techniques in the context of healthcare, the vast array of techniques available and the wide diversity of activities. The most widely applied human error identification and analysis technique in healthcare is Failure Modes Effect Analysis which involves using a team of multidisciplinary experts to evaluate the process and determine what actions could reduce potential failures identified in the process and has been applied to transfusion and drug therapy[6,7].

Specific techniques aside, there are two principal approaches to error investigation, the person approach and the system approach[8]. The person approach is all too common in healthcare. It focuses on unsafe acts and the individuals involved, blaming them on forgetfulness, inattention, negligence and recklessness. Preventative measures are targeted at reducing unwanted variability in behaviour. These approaches include strategies such as educational frameworks but others utilise new technology and this is discussed in more detail later. One of the conclusions of the Institute of Medicine report was that the majority of medical errors do not result from individual recklessness, that this is not a 'bad apple problem'. A serious weakness of the person approach is that it separates the error from the context in which it occurred.

The system approach assumes that human subjects are fallible and that errors are to be expected; these errors are approached as consequences rather than causes. Countermeasures are targeted not at changing the human condition but in changing the latent conditions that human subjects work under. The approach requires exploration of these conditions such as equipment design, procedural complexity, time pressure, understaffing, fatigue and inexperience.

Mistakes do happen in the provision and prescription of PN and the consequences can be devastating[9]; it is important that lessons are learnt from these tragic events and measures put in place to prevent their recurrence. In order to do that, we must understand how quality is compromised. When applying human error theory to PN services it is possible to pin-point where errors may occur.

Organisational processes and management factors may include purchasing decisions, staffing decisions and bed management issues. Examples of error-producing conditions during a routine nutrition ward round could be factors

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such as a large number of patients to be reviewed before the deadline for prescription ordering, frequent interruptions during the prescribing process or misinformation due to poor-quality medical records. Violation-producing conditions are those where the operator knew there was a procedure or process but they chose to violate it; this is rarely malicious in intent, it usually stems from a culture of ignoring certain procedures because they are timely or cumbersome and a lack of understanding of the consequences of such action. An example of such behaviour is a carer deciding not to use a giving set with an inline filter when administering the PN because in their experience they sometimes block, but the carer does not realise that the filter is protecting the patient from particulates in the infusate and that filter blockage may indicate an underlying problem with the stability of the regimen[10,11].

These conditions lead to the mistakes, slips, lapses and violations that can result in an error. In order to safeguard the patient and maintain quality, we put in barriers to prevent errors from reaching the patient. These could be ensuring adequate staffing grades on the nutrition team, only allowing specifically trained nurses to administer PN or cohorting patients in a reduced number of ward locations so that staff can be more familiar with the procedures and monitoring for these patients.

In order to appropriately target safeguards, we must be aware of the types of errors that can happen. This is the value of a national database of incidents and near misses. The National Patient Safety Agency (NPSA) national reporting and learning system (NRLS) was established in 2005 to enable the monitoring, review and prevention of medication safety incidents. It was through this system that the scale of the issues surrounding safe practice in enteral nutrition were identified. BAPEN had already taken an early lead in this issue producing its guidance in 2003 (BAPEN Resources for Drug Administration via enteral feeding tubes. http://www.bapen.org.uk/res_drugs.html), and worked with the NPSA, alongside our colleagues in industry, to inform the content of the patient safety alert published in 2007[12].

As with all self-reporting systems there are shortfalls with the NRLS system; there is an understanding that actual incident frequency will be far higher and there is also a lower reporting of 'near-misses' and incidents with no harm outcomes. There is also a difference in reporting culture, with nurses and pharmacists being more likely to report an incident than their medical colleagues[13]. That aside, these data can be a powerful force for change and many medicine policy changes have come about as a result of this work.

It is important that this information is accessible and can be used to improve the systems and processes in nutrition service design. A review of the reports from the NRLS system between 1 June 2009 and 1 June 2010 identified 670 errors relating to PN[14]; this is a high number of incidents for a single therapeutic area. A brief thematic analysis of these reports was undertaken by NPSA staff. The most common errors reported, accounting for 49%, were related to the administration or supply of a medicine from a clinical area, and comprised incorrect infusion rates or wrong product selection. Errors relating to preparation and dispensing, accounting for 24%, related mainly to incorrect labelling such as wrong hospital number or name. There were no fatal incidents within these data.

A specific example cited in the safety in doses report from 2009[15] from analysis of the 2008 data relates to a fatal outcome associated with the mismanagement of PN by a non-specialist team. Although the full details of this tragic incident are not specified, it does highlight a number of potential system failures. From the details cited, there appears to be no appreciation that the prescription of PN required specialist input from the nutrition support team. Potentially because of this lack of specialist input, the patient was not monitored appropriately. The ward nurses administered an intravenous medication without prescription; not only is this illegal but also the absence of a prescription meant that other safety systems such as the pharmacist review of the drug chart were bypassed. Although human error was involved, had there been referral systems in place, this fatal incident may have been avoided.

The data available from these incident reports are highly variable in content and quality and therefore a highly robust analysis of the data is not possible; however, there are sufficient data and a worryingly high number of reports to warrant further analysis and investigation of these incidents. In order to provide an evidence base for more detailed safety guidance relating to PN a full analysis of the NRLS data should be undertaken and a programme of works developed to improve safety in this clinical area.

Early in 2010, the American Society for Enteral and Parenteral Nutrition launched an initiative, in conjunction with the Institute for Safe Medication Practices, to encourage the reporting of nutrition-related incidents[16]. This presents a unique opportunity to combine UK and US safety data to develop international safety standards and guidance.

Providing a safe solution

The quality of the nutrient solution is dependent on many factors; these include the appropriateness of the prescription, the composition of the regimen, the source of the ingredients, the compounding environment and process and the stability of the admixture.

Despite the evidence that administration errors are the most common, the prescription and provision of the PN solution are often perceived as the highest risk. When PN as a therapy was in its infancy the provision of quality nutrition solutions was a challenge. In the 1980s the ward-based risks of multiple bottles and bags and variable infusion rates were exchanged for a whole new set of risks transferred to pharmacy, those of aseptic manufacture and stability assurance.

At the time there was recognition of the complexity and responsibility of prescribing and compounding a stable nutrition admixture that was chemically and microbiologically safe for intravenous infusion. The prescription forms resembled recipe cards, and there was a transparent dialogue between the prescriber and pharmacy. It was through extensive research into all aspects of nutrient

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solution stability we were assured that all-in-one nutrition regimens could be used safely. So much of this work is now taken for granted.

Technology and products have continued to develop since the introduction of licensed nutrition solutions into clinical practice. We are closer than ever to defining the ideal composition of a PN solution.

A PN regimen should be appropriate to the patients' nutritional requirements and must contain all the necessary components; water in an appropriate quantity to meet the patient's fluid requirements, amino acids, both essential and non-essential in proportions suitable for the patient, for example, neonatal solutions mimicking cord blood or breast milk in their profile, and a lipid source with an emulsion particle-size profile similar to chylomicrons and be provided in a quantity appropriate to the patient's requirements. Glucose must be provided with consideration to nutritional demands and metabolic limitations. Electrolytes should be provided in sufficient quantities to prevent deficiencies and minimise toxicity and in appropriate salt forms to maintain metabolic balance. Vitamins and minerals should be included to ensure effective metabolism of the macronutrients.

That a PN solution should be nutritionally complete is well known, but there are so many other properties that are also essential. If providing an all-in-one admixture it must be a stable emulsion system; this requires the correct balance of attractive and repulsive forces to ensure the emulsion does not crack. It can be influenced by the type of lipid as well as the quantity, but it is also influenced by the pH of mixture that can be affected by the glucose concentration and the buffering capacity of the amino acids.

Other aspects of physical stability should also be considered such as the risk of precipitation. Ca and PO_4 are the primary concern, influenced not only by the concentrations included but also the salt forms, the amino acid source, temperature and Mg concentration[17]. There is also a risk of trace element precipitation. Chemical stability is also a concern; consideration should be given to the oxidation of ascorbic acid catalysed by Cu ions, the influence of light on vitamins A and E stability and the effect of temperature and pH.

There are increasing concerns over certain areas of stability particularly high-volume dilute regimens and low-volume concentrated regimens, also vitamin–mineral–electrolyte combinations; once again clinical practice is beginning to push the limits of the available stability data. As new products come onto the market, consideration must be given to developing stability information to support their use in clinical practice.

PN is an effective growth medium; absolute sterility should be the goal of any aseptic compounding process. In addition to microbial contamination, the risk of other contaminants such as Al should be considered, especially in light of the recent alert relating to calcium gluconate[18]. Particulate contamination is also an issue; it can never be completely eliminated and therefore a terminal in-line filter should used[19].

The final presentation of the product may seem inconsequential but the type of material used for the bag will influence oxygen permeation and therefore stability. Covering the bag will reduce the effects of light on vitamin stability[17]. Delivery cold chain must be assured to optimise shelf life.

Due to the number and range of individual ingredients in PN there is theoretically an infinite number of combinations and permutations of regimens that could be requested. However, in clinical practice in the UK the majority of PN is now based on commercially available standard bags, with additions within validated stability ranges. Clinical discussions are increasingly focused on the risks and merits of 'standard bags'.

Standardisation as a risk reduction strategy

Since the early 1990s, the evolution of PN products and the era of standardisation have offered opportunities to manage aseptic services workload more effectively and increased confidence in the stability of the finished compounded products.

There have been many advocates for the use of standardised regimens with proposed advantages focusing on the cost, time and complexity of the prescription and preparation of these products[20]. The use of pre-compounded base bags has been demonstrated to reduce preparation times, wastage and costs[21]. There is evidence that a limited range of regimens can meet most patients' macronutrient requirements[22] and through limiting available regimens and increasing familiarity there is a potential reduction in prescribing errors[23]. However, to date, there remains little robust evidence evaluating the clinical impact of these products. In the economic evaluation of standard bags undertaken by Pichard *et al.*[22] no data were collected on additional supplements that may have been required due to the incomplete nature of these products and therefore even the proposed cost reduction through the use of these products may be overestimated.

Standard PN has been clinically evaluated in neonatal care and demonstrated to be inferior to individualised PN[24]. In a study of 140 neonates, those on individualised PN had significantly better weight gain, discharge weight and head size received less electrolyte corrections and significantly shorter duration of exclusive PN. More studies of this calibre are required in all applications of standard bags.

Over the last 10 years, there has been an explosion of commercially available dual- and triple-chamber 'ready-to-use' bags onto the UK market with well over sixty different regimens now available. They have several advantages, they are licensed products and therefore, until manipulated, quality is assured. They also have defined and validated stability limits for a range of additions, with guaranteed shelf life from the manufacturer. However, these products were designed to reduce pharmacy workload, they were never originally intended to be used 'off-the-shelf' as they require aseptic manipulation to be nutritionally 'complete'. Once additions are made, the product is no longer licensed and the value of guaranteed composition and sterility is compromised.

The range of regimens available commercially contains 'conservative' quantities of electrolytes, and therefore additional supplementation is often required. There is an

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emergence of novel substrates and newer lipid preparations as components of commercially available bags. By the very nature of the product and the heterogeneity of this patient population they are not suitable for all patients. In 2008, the British Pharmaceutical Nutrition Group produced a position statement on the safe use of standard bags[25] and although predating the NCEPOD report by 2 years, its recommendations were very similar. The key recommendations were: prior to initiation of PN the patient must undergo a nutritional assessment by a competent professional; there must be an appropriate indication; if pre-mixed bags are used they must closely match the patients requirements; no additions should be made to these bags at ward level and that these convenience products should not be freely available at ward level.

A combination of developments in 'off-the-shelf' products and underfunding of hospital aseptic units has served to strip out much of the knowledge, skills and infrastructure that is necessary to provide anything more than a 'simple' PN regimen. The NCEPOD data indicate that standard bag use is now a significant part of how PN services are delivered in practice. Of 935 adult patients with available data, over 42% did not receive micronutrients in the PN and over 65% did not receive tailored electrolytes. Hypokalaemia, hypomagnesaemia and hypophosphatemia were among the most common reported adverse effects of PN therapy. This implies that standardised products may not be clinically appropriate for use 'off-the-shelf' due to inadequate quantities of these electrolytes.

The potential consequences of using these products 'off the shelf' must be considered. If the products are freely available at ward level, there is no assurance that the product selected will be appropriate for the patient, or that it will be prepared correctly, potentially resulting in the infusion of a single component of a multiple chamber product. A full risk assessment should be undertaken before these products are held as unrestricted stock at ward level, and clear guidance and training must be provided to mitigate the inherent risks. If these products are used 'off-the-shelf', vitamins and minerals must be given as separate infusions and additional parenteral electrolyte supplementation may also be required, particularly in those who develop re-feeding syndrome. This will result in increased ward-based activity in prescribing, preparation and administration.

The balance of risks: ward-based *v.* pharmacy-based preparation

Despite the uptake of standard bags, there is little research evaluating their use in clinical practice, and none quantifying the increase in additional supplementation required. This kind of research is urgently required. Ward-based preparation of injectables is a high-risk process and the multiple steps in the procedure provide many opportunities for human error[26,27]. In a recent observational study there were one or more errors detected in 49% of intravenous doses[28]. In an analysis of observational studies, the most common errors were diluent selection and reconstitution, administration (particularly injection or infusion rate) and confirmation of allergy status[29].

On review of the electrolyte abnormalities identified in the NCEPOD report, it is reasonable to presume that additional supplementation of K, Mg or PO_4 may be indicated for many patients on 'standard' PN. Risk issues associated with K were addressed several years ago by the NPSA[30] with a tight restriction on which areas can use strong K-containing injections, and a standardisation of ready-made infusions. However, correction of hypokalaemia using these products can result in excessive fluid delivery due to the low concentrations of the available products. Mg infusions are a source of possible error due to the different dosing guidelines dependent on the indication and the confusing labelling of percentage, mmol or g. In addition an incorrect infusion rate can result in renal loss of Mg rather than repletion.

PO_4 repletion is also an issue with many centres using complex dosing calculations based on mmol/kg dosing regimens in an attempt to implement evidence-based practice. The commercially available PO_4 products are not ready to use, containing either high doses or concentrated solutions requiring dilution, some of which are classed as strong K solutions.

As a response to the number of incidents relating to ward-based preparation of injectables and following the guidance of the NPSA[31] a programme of works is now underway to deliver ready-to-use preparations, which reflect commonly prescribed doses and dilutions of high-risk products, such as those requiring multiple ampoules for a single dose or serial dilutions. Pharmacy departments are now trying to find the capacity to take back this work from the ward; increasing the use of standard bag PN is seen as a way of releasing capacity within aseptic services.

The reason for preparing preparations in pharmacy or specific aseptic units is to minimise risks associated with preparation in clinical areas. This is achieved through rigorous quality-assured processes in an aseptic environment.

But in everything, human error can never be eliminated. Pharmacy has developed quality checks into every step of the production process to ensure that risks are minimised. The national aseptic error reporting scheme has been collecting data from forty-three pharmacy aseptic manufacturing centres around the UK since 2003. A recent analysis of data (spanning 4 years), equating to almost a million manufactured items indicated that internal error rate within these departments was less than half a percent, with only half a percent of these reaching the patient[32]. This is drastically lower than ward-based activity and yet the current trend is to reduce pharmacy-based activity due to the costs and a lack of understanding of the clear benefits.

Utilisation of technology to reduce the impact of human error

Frequently the response to errors in healthcare is to turn to technology; its perceived value is in the removal of human error. There is a vast array of technology that can be used effectively to deliver safer healthcare systems, not all of it high tech. Measures as simple as wearing a 'do-not-disturb' tabard while administering medicines has been

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shown to have a positive impact. However, all system changes, including the introduction of technology, require effective evaluation both before and after implementation.

Information and computerised technology have been utilised to deliver computer-aided education and training, and this allows for individual training through text and cases and evaluation through embedded questions. This approach reduces the resources required when compared with face-to-face teaching and can be undertaken at a time convenient to the student. Unique user login allows tracking of participants and an organisational record of training uptake. The BAPEN MUST e-learning module is one such programme.

Information technology can be utilised to reduce the effect of human error. Using computer-aided design and decision making are considered to reduce errors and work well for simple processes. Computerised prescribing systems have been used to good effect, particularly in paediatric and neonatal PN. The highly complex nature of the calculations makes this process fraught with errors. Computerised systems have been shown to reduce these errors from 10 to 1·2%[33] that reduces the subsequent time spent liaising between pharmacist and prescriber. However, the development of computerised prescribing systems for PN is highly complex and relies on rule-based decisions and extensive validation. The high variability in approach to prescribing PN is evident by the fact that there is limited availability of computer-aided PN prescribing systems; all the published literature refers to in-house-developed systems.

Electronic transfer of information and automatic worksheet and label production can reduce the risk of transcription errors and the misplacement or loss of decimal places. The use of barcode technology is developing rapidly and has already been used to improve the safety of blood transfusion. Its impact on medication errors particularly drug, dose and patient selection are significant, with reported reductions in error rates of 50%[34]. The advances in two-dimensional barcoding allow for the inclusion of both product and patient information allowing for this to be checked against the patient's wristband. In the future it may be possible to integrate this information into infusion pump technology to reduce the risk of incorrect infusion rate.

The effective use of technology relies on a standardisation of processes, doses and concentrations; within a highly complex therapeutic area such as nutrition this provides many challenges. The use of information and computerised technology requires an organisational approach to avoid potential system integration issues. A robust system of validation must be undertaken before any system goes live and full post-implementation evaluation must be undertaken to ensure that additional risks have not been introduced into the system.

Applying quality control processes to clinical practitioners

Historically qualifications and years of experience were used as the criteria for recruitment and selection, but increasingly a demonstration of competence is required. Competence is more than knowledge and attending courses, but defining competence can be difficult particularly when it includes intangible and subjective factors such as judgement. Competency frameworks aim to crystallise that information and set out the attributes required for effective performance at predefined levels.

The recent introduction of non-medical prescribing has provided a very practical application for the competency frameworks, and in recent years both the British Pharmaceutical Nutrition Group and the National Nutrition Nurses Group have developed frameworks to support professionals working in these specialist areas[35,36]. The new specialist training curriculum for gastroenterology is also competency based (Specialty Training Curriculum for Gastroenterology, August 2010). On review of the competences outlined in the recent documents there is significant overlap between professions.

In every framework for each individual there will be aspects that are mandatory and aspects that are aspirational. There will be fluidity between levels, with the assumption that once individuals are competent at one level they would continue to develop skills in the next. Skills do not develop at equal rates and there are certain competencies that are more difficult to achieve and demonstrate.

Competency frameworks are be used as a tool to facilitate individual continuing personal development, to identify training needs, to assist with performance review, to inform the recruitment process, to inform local and national training programmes and to ensure consistency in commissioning. Accepted levels of staffing competence can be built into commissioned services[37], ensuring that changes in staffing does not impact on the service.

So who should be responsible for defining and assessing competence in specialist nutrition support? Is this the role of a nutrition society? In 1984, the American Society for Enteral and Parenteral Nutrition, established an independent credentialing board: until 2008, there were separate exams for clinicians, nurses, dietitians and pharmacists. A review of the syllabi in 2008 revealed a considerable overlap and a single qualification was introduced for all practitioners in nutrition support. The syllabus is far-reaching covering all aspects of nutritional assessment and therapeutic applications of oral, enteral and parenteral therapy as well as associated drug therapy and drug nutrient interactions. There are eligibility criteria and a 200 multiple-choice exam paper, a requirement for demonstration of annual continuing personal development and re-accreditation every 5 years. Considering the overlap between the emerging competency frameworks in the UK, there may be a role for BAPEN in ensuring consistency and driving standards.

Conclusion

PN is a high-risk therapy; the quality of its delivery should not be entirely dependent on the skills, knowledge and competence of those delivering this care but on accepted standards, procedures, communication, resource

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and infrastructure. It is essential that quality assurance is built into every step of the process not just in the solution provision. It is possible to identify and audit quality throughout the process of providing PN from referral to discontinuation. An analysis of the critical steps allows us to pinpoint where quality may be compromised and where safeguards can be put in place within our own organisations.

There is an opportunity to use the information from the NRLS for shared learning, to foster a no-blame culture and really understand and address PN-related errors; working together in the best interests of the patient, utilising the emerging networks to disseminate this information. As clinical practitioners, we have a responsibility to ensure that service provision redesign and high-risk process transfer from one clinical area to another, such as from pharmacy to the ward, does not adversely affect patient care. Specifically, more research is required on the clinical and economic implications of standard bag use.

Moving forward BAPEN faces many challenges: to support the members of these teams to deliver quality nutritional services within the changing NHS; to ensure that cuts do not compromise quality and safety; and a responsibility to patients to ensure that their care and safety remain the key priority. BAPEN must continue to ensure that quality nutritional care is embedded in NHS policy throughout the UK. BAPEN continues to have a key role in the support and develop of education in nutrition.

BAPEN must maintain the focus on the essential ingredients for the provision of quality nutrition; to raise awareness of the importance of appropriate nutrition support, ensure that standards continue to be developed and implemented, through the effective use of data from the British Artificial Nutrition Survey, and work with the existing HPN (home PN) networks in Scotland and Wales and the emerging English HPN and intestinal failure network to ensure that quality standards are embedded in the implementation of that network.

Professor Pennington was an advocate for quality in all aspects of nutrition support and its delivery. He ensured that the patient remained at the centre of all decisions, and that specialist artificial nutrition support was best managed by the multidisciplinary nutrition team and the education of the wider healthcare community. His involvement in both strategic service development and grass roots education can be a lesson to us all.

'Make the care of patients your first concern' is the primary principle of every healthcare professions code of ethics. We must keep the patient and their safety at the centre of all decisions; delivering a quality service must remain our goal.

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References

1. NCEPOD (2010) A Mixed Bag – An enquiry into the care of hospital patients receiving parenteral nutrition. NCEPOD. June 2010.
2. National Collaborating Centre for Acute Care (2006) Nutrition support in adults Oral nutrition support, enteral tube feeding and parenteral nutrition. National Collaborating Centre for Acute Care, London; available at http://www.rcseng.ac.uk
3. Department of Health (2010) Equity and excellence: Liberating the NHS. Department of Health, July 2010.
4. Kohn LT, Corrigan JM & Donaldson MS (eds.) (2000) *To Err is Human: Building a Safer Healthcare System*. Washington, DC: Institute of Medicine, National Academy Press.
5. Department of Health (2000) An organisation with a memory. London: Department of Health.
6. Burgmeier J (2002) Failure mode and effect analysis: An application in reducing risk in blood transfusion. *Jt Comm J Qual Improv* **28**, 331–339.
7. Apkon M, Leonard J, Probst L *et al.* (2004) Design of a safer approach to intravenous drug infusions: Failure mode effects analysis. *Qual Saf Health Care* **13**, 265–271.
8. Reason J (2000) Human error: Models and management. *Br Med J* **320**, 768–770.
9. FDA (1994) FDA Safety Alert: Hazards of Precipitation Associated With Parenteral Nutrition. April 1994.
10. Ball PA (2001) Methods of assessing stability of parenteral nutrition regimens. *Curr Opin Nutr Metab Care* **4**, 345–349.
11. Rubin M, Bilik R, Aserin A *et al.* (1989) Catheter obstruction: Analysis of filter content of total nutrient admixture. *JPEN* **13**, 641–643.
12. NPSA (2007) NPSA Patient Safety Alert 19. Promoting safer measurement and administration of liquid medicines via oral and other enteral routes. March 2007.
13. Sarvadikar A, Prescott G & Williams D (2010) Attitudes to reporting medication error among differing healthcare professionals. *Eur J Clin Pharmacol* **66**, 843–853.
14. NPSA (2010) Personal Communication. NPSA. August 2010.
15. NPSA (2009) Safety in Doses: Improving the use of medicines in the NHS. NPSA. September 2009.
16. ASPEN (2010) Reporting Parenteral and Enteral Nutrition Therapy and Device related errors; available at http://www.nutritioncare.org
17. Allwood MC & Kearney MCJ (1998) Compatibility and stability of additives in parenteral nutrition admixtures. *Nutrition* **14**, 467–706.
18. MHRA (2010) New contraindications for calcium gluconate injection in small-volume glass containers. *MHRA Drug Safety Update* **4**(1), 3–4.
19. Bethune K, Allwood MC, Grainger C *et al.* (2001) Use of filters during the preparation and administration of parenteral nutrition: Position paper and guidelines prepared by a British Pharmaceutical Nutrition Group working party. *Nutrition* **17**, 403–408.
20. Puntis J (2010) Safe parenteral nutrition and the role of standardised feeds. *Signa Vitae* **5**, 8–12.
21. Maswoswe JJ, Newcomer DR & Quandt CM (1987) Achieving parenteral nutrition cost savings through prescribing guidelines and formulary restrictions. *Am J Hosp Pharm* **44**, 1376–1381.
22. Pichard C, Schwarz G, Frei A *et al.* (2000) Economic investigation of the use of three-compartment total parenteral nutrition bag: Prospective randomized unblinded controlled study. *Clin Nutr* **19**, 245–251.

https://doi.org/10.1017/S0029665111000541 Published online by Cambridge University Press

23. Petros WP & Shank WA (1986) A standardised parenteral nutrition solution: Prescribing, use, processing and material cost implications. *Hosp Pharm* **21**, 648–649, 654–656.
24. Smolkin T, Diab G, Shohat I *et al.* (2010) Standardized versus individualized parenteral nutrition in very low birth weight infants: A comparative study. *Neonatology* **98**, 170–178.
25. BPNG (2008) Position Statement on the use of multi-chamber parenteral nutrition bags for use in adult patients; available at http://www.bpng.co.uk
26. McDowell SE, Ferner HS & Ferner RE (2009) The pathophysiology of medication errors: How and where they arise. *Br J Clin Pharmacol* **76**, 605–613.
27. O'Hare MCB, Bradley AM, Gallagher T *et al.* (1995) Errors in administration of intravenous drugs. *Br Med J* **310**, 1536.
28. Taxis K & Barber N (2003) Causes of intravenous medication errors: An ethnographic study. *Qual Saf Health Care* **12**, 343–348.
29. McDowell SE, Mt-Isa S, Ashby D *et al.* (2010) Where errors occur in the preparation and administration of intravenous medicines: A systematic review and Bayesian analysis. *Qual Saf Health Care* **19**, 341–345.
30. NPSA (2002) NPSA Patient Safety Alert Potassium Chloride Concentrate Solution. October 2002.
31. NPSA (2007) NPSA Patient Safety Alert 20. Promoting Safer use of injectable medicines. March 2007.
32. Bateman R & Donyai P (2010). Errors associated with the preparation of aseptic products in UK hospital pharmacies: Lessons from the national aseptic error reporting scheme. *Qual Saf Health Care* **19**(5), e29.
33. Lehmann CU, Conner KG & Cox JM (2004) Preventing provider errors: Online total parenteral nutrition calculator. *Pediatrics* **113**, 748–753.
34. Poon EG, Keohane CA, Yoon CS *et al.* (2010) Effect of bar-code technology on the safety of medication administration. *NEJM* **362**, 1698–1707.
35. BPNG (2008) *BPNG Competency Framework for Specialist Nutrition Pharmacists*, 1st edn., available at http://www.bpng.co.uk
36. NNNG (2010) *A Competency Framework for Nutrition Nurse Specialists*, 1st edn., available at www.nnng.org
37. Department of Health (2008) A strategic framework for intestinal failure and home parenteral nutrition services for adults in England. April 2008. National Commissioning Group for Highly Specialist Services. Department of Health.

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