THE IMPACT OF ONGOING AUDIT ON NUTRITIONAL SUPPORT IN PAEDIATRIC INTENSIVE CARE

Thesis
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Confidentiality: A

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DECLARATION OF ORIGINAL WORK

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

Signature: 26-10-2004

ABSTRACT

Objective: To assess the impact of a continuous auditing process on nutritional support in a tertiary paediatric intensive care unit.

Design: Prospective, longitudinal audit initiated in 1994. Re-auditing took place almost every 2 years: 1994-1995, 1997-1998 and 2001, leading to completion of the audit cycle.

Setting: An 8 bed Paediatric Intensive Care Unit (PICU) in St.Mary's Hospital London.

Subjects: All ventilated patients admitted for more than a complete 24-hour period were included in the audit. The units' standard daily fluid charts were used for data collection. Data was collected until discharge from PICU or a maximum of 10 days. Incomplete and imprecise data was disregarded during the data analysis process.

Outcome measures and interventions: The outcome measures include time taken to initiate nutritional support, the route of feeding and delivery of calories by day 3, judged by the Estimated Average Requirements (EAR) for energy. Feeding algorithms and protocols introduced after each audit: nasogastric feeding algorithm following the 1994-1995 audit, blind nasojejunal tube insertion technique and related feeding algorithms after the audit in 1997-1998.

Results: Time taken to initiate enteral feeding was reduced from 15 hours (1994-1995) to 5.5 hours (2001). The proportion of parenterally fed patients fell from 11% (1994-1995) to 1% (2001). The proportion of enterally fed patients via the nasojejunal route rose from 1% (1994-1995) to 20% (2001). An increase was noticed in patients reaching 50% and 70% of energy requirement by day 3 following admission was documented: 7% in 1994-1995 to 35% in

2001 for 70% of EAR ($p = 0.0008$) and 18% in 1994-1995 to 58% in 2001 for 50% of EAR. ($p < 0.0001$)

Conclusion: This audit process demonstrates the effectiveness of continuous auditing in an intensive care unit in improving the quality of nutritional support. This is possible only with a multi-disciplinary team approach.

ABSTRAK

Doel: Om die impak van 'n deurlopende ouditerings proses op die voedingsondersteuning in 'n tersiêre pediatriese intensiewesorg-eenheid te evalueer.

Studie Ontwerp: 'n Prospektiewe, longetudinale oudit is in 1994 geïnisieer. Herouditeering het ongeveer elke 2 jaar plaasgevind: 1994-1995, 1997-1998 en 2001. Dit het tot die voltooiing van 'n ouditering siklus gelei.

Plek: 'n Agt-bed Pediatriese Intensiewesorgeenheid (PISE) in St.Mary's Hospitaal London, Engeland.

Pasiënte: Alle geventilleerde pasiënte wat opgeneem was vir langer as 'n volledige 24 uur-periode is by die oudit ingesluit. Die eenheid se standard daaglikse vogkaarte dokumentasie is gebruik vir data-insameling. Data-insameling het plaasgevind tot en met ontslag vanuit die PISE vir 'n maksimum van 10 dae. Onvolledige en onakkurate data is uitgesluit tydens die data analise proses.

Uitkomste en Intervensie: Die uitkomste is gemeet deur die impak van die ouditerings proses te evalueer ten opsigte van tydsduur voordat daar voedings geïnisieer is, die voedingsroete en die hoeveelheid energie gelewer teen dag 3, vergelyk met die geskatte gemiddelde energie behoefte. Voedings-algoritmes en protokolle is geïmplementeer na elke oudit: nasogastriese voedings-algoritmes is na die 1994-1995 oudit geïmplimenteer, 'n blinde nasojejunale buisinplasingstegniek en relevante voedings algoritmes het na die 1997-1998 oudit gevolg.

Resultate: Die tydsduur om voedingondersteuning te inisieer het van 15 ure (1994-1995) tot 5.5 ure (2001) verminder. Die persentasie pasiënte wat parenterale voeding ontvang het, het gedaal van 11% (1994-1995) tot 1% (2001), met 'n toename in enterale voeding via die nasojejunale roete van 1%(1994) tot 20% (2001). 'n

Toename in pasiente wat meer as 50% en 70% van hul energie behoefte bereik het teen dag 3 is opgemerk: 7% in 1994-1995 en 35% in 2001 het meer as 70% van die geskatte gemiddelde behoefte vir energie ontvang. (p=0.0008) Agtien persent het in 1994-1995 en 58% in 2001 meer as 50% van hul gemiddelde energie behoeftes bereik ($p < 0.0001$).

Gevolgtrekking: Hierdie ouditerings proses demonstreer die effektiewiteit van deurlopende ouditering in 'n intensiewesorg-eenheid deur die verbetering van die kwalitiet van voedingondersteuning. Dit is slegs moontlik met 'n multidissiplinêre span benadering.

DEDICATION

Do not stand at my grave and weep;

I am not there. I do not sleep.

I am a thousand winds that blow.

I am the diamond glints on snow.

I am the sunlight on ripened grain.

I am the gentle autumn rain.

When you awaken in the morning's hush

I am the swift uplifting rush

I am the soft stars that shine at night.

Do not stand at my grave and cry;

I am not there. I did not die.

Unknown Poet

To the children whose lives have been cut so tragically short, and to those whom I had the privilege to care for over the years, to my colleagues for the unstinted support and to my parents and family for their wisdom and unconditional love.

LIST OF ABBREVIATIONS

ATP	Adenosine Triphosphate
CIC	Critically Ill Child
CoA	Coenzyme A
DO_2	Delivered Oxygen
EN	Enteral Nutrition
EAR	Estimated Average Requirements
F_{iO2}	Fraction of Inspired Oxygen
GALT	Gut Associated Lymphoid Tissue
GIT	Gastrointestinal Tract
HPN	Home Parenteral Nutrition
IL-1	Interleukin -1
IV	Intravenous
MODS	Multiple Organ Dysfunction Syndrome
NBM	Nil by mouth
NJ	Nasojejunal
NHS	National Health Service
PICU	Paediatric Intensive Care Unit
PRISM	Paediatric Risk of Mortality
PN	Parenteral Nutrition
PBMR	Predicted Basal Metabolic Rate
REE	Resting Energy Expenditure
RDA	Recommended Dietary Allowance
SIRS	Systemic Inflammatory Response Syndrome
TCA	Tricarboxylic Acid

TNF	Tumour Necrosis Factor
UK	United Kingdom
VO_2	Oxygen Volume

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CHAPTER 1: INTRODUCTION

The new millennium has disappointed many by not providing the answers to numerous sought after clinical questions. Many of these relate to the nutrition of critically ill children (CIC), which will consequently remain a challenging area, with exiting but often controversial new advances being made.

Paediatric intensive care units (PICU) are a relatively new concept. They are run separately from adult intensive care units and are staffed by specially trained intensivists, nurses and allied health staff. Because they are relatively rare, with only 35 specialists and general units in the United Kingdom (UK) many CIC are still cared for in adult units. By implication, therefore, the field of nutrition research and clinical practice specific to CIC is lacking firm evidence base, with current feeding practices relying heavily on the principles established from adult studies [1, 2]. Existing data does however suggest that extrapolating adult data for paediatric use can lead to inappropriate feeding regimens with detrimental and even fatal consequences[3]. In particular, there seem to be significant differences in the effect of critical illness on energy and substrate metabolism. Adult data has shown that a hypermetabolic state occurs during critical illness, characterized by energy expenditure that is significantly greater than that in a normal resting non-stressed state [4]. Plank et al proposes that the resting energy expenditure (REE), in adults with severe sepsis, can be up to 49% above normal [5]. On the contrary preliminary studies in CIC have not demonstrated a similar hypermetabolic response. Therefore extrapolation from adult studies may result in the child receiving an excessive amount of energy. Overfeeding can lead to an increased carbon dioxide production, resulting in poor ventilatory weaning as well as diarrhoea associated with electrolyte imbalances and other well documented metabolic and physical complications [6, 7]. On the other hand, there are concerns regarding underfeeding, a more common occurrence in the CIC [8]. This leads to undernutrition with the related complications resulting in impaired muscle strength[9], reduced wound healing due to altered immunity[10] and increased rates of sepsis [9]. Thus, providing the correct energy prescription in crucial.

The goal of nutrition support during critical illness is to sustain organ function and prevent dysfunction of the cardiovascular, respiratory and immune systems. In addition, nutrition support in this subset of patients can minimize the starvation effects associated with suboptimal alimentation, prevent nutritional deficiencies and support the patients' disease state until the acute-phase inflammatory response resolves [3]. Both the above mentioned under- and over-nutrition have the potential to compromise this aim and significantly complicate and increase the stay in an intensive care unit [8, 11]. The mean stay in a PICU is 4-5 days [12]. Increasing the bed days in hospital has been linked to an increase in nosocomial infections and other treatment related side effects, which in turn may have severe cost implications [13]. Adequate nutritional support, therefore, has the potential of reducing both the morbidity and mortality of a patient admitted to an intensive care unit.

According to the British Paediatric Association, 12 888 children and juveniles were admitted to either paediatric or adult intensive care units in 1991 in Great Britain. This amounts to almost 1.2 in 1000 children and juveniles of the total population between 0-16 years of age [14]. Intensive care, like all other medical care in the UK falls under the nationalized health system. Contrary to other clinical areas, it is a low volume, high cost specialty which depends on highly trained and skilled staff and the availability of specialized equipment [14]. Taking the above statistics into account, there is little doubt that inappropriate and ineffective care on a PICU has serious social, economic and medical implications to the patient as well as the National Health Service (NHS) [15]. Improving nutritional practices, therefore, has the potential to not only benefit patients' outcome, but also to have a financial impact on the health service. Schwartz and Fraser et al has estimated annual savings due to reduced intensive care bed days, to be $700 000 annually for the 28 bed intensive care unit where the study was performed [16,17] .

A key factor in improving alimentation in a PICU is assessing current practice. Clinical governance is the main vehicle for improving the quality of patient care in NHS and has been defined as "a quality improving process that seeks to improve patients care and outcome [18], through systematic review of care against explicit criteria and the implementation of change" [19]. Auditing and the development of clinical guidelines are the mainstay of clinical governance. Auditing, as defined by The National Institute for Clinical Excellence has been appointed as the governing body monitoring clinical governance [19]. This practice (auditing and the subsequent development of clinical guidelines) has been actively promoted by the NHS.

Many hospitals and centers have already adopted this practice with striking results. An outstanding example is the audit done by the Home Parenteral Nutrition (HPN) Managed Clinical Network, which has audited all aspects of HPN, highlighting the need for continuous professional development for health professionals dealing with HPN and the need to make the process continuous [20]. This audit enabled observers to evaluate the implemented changes and monitor the quality of care on a continuous basis [21] .

St.Mary's Hospital (London) founded its PICU in 1992. A dietetic service was first provided in 1994 through the provision of a full time paediatric dietitian. At that time there were no formal local or national guidelines to direct nutritional practice in CIC and as a result nutritional practices varied. In line with the NHS audit initiative, the audit of nutritional practices on PICU was started in 1994 and repeated between 1997-1998 and 2001. This process allowed identification of areas of nutritional practice that needed to be addressed. The challenge was the implementation of new practices that would lead to improved nutritional support in CIC.

Several studies have shown that feeding protocols may assist in achieving optimal nutritional care in CIC. Protocols for early enteral feeding and transitional feeding have been introduced successfully in PICU's with striking results: reaching energy requirements at a faster rate and improving the transition from parenteral (PN) to enteral nutrition (EN) [22, 23]. Similarly, protocols in the form of feeding algorithms were developed and introduced to PICU at St.Mary's Hospital. Each audit was followed by the implementation of a new feeding algorithm, geared towards the specific area that needed to be improved. (Figure 1)

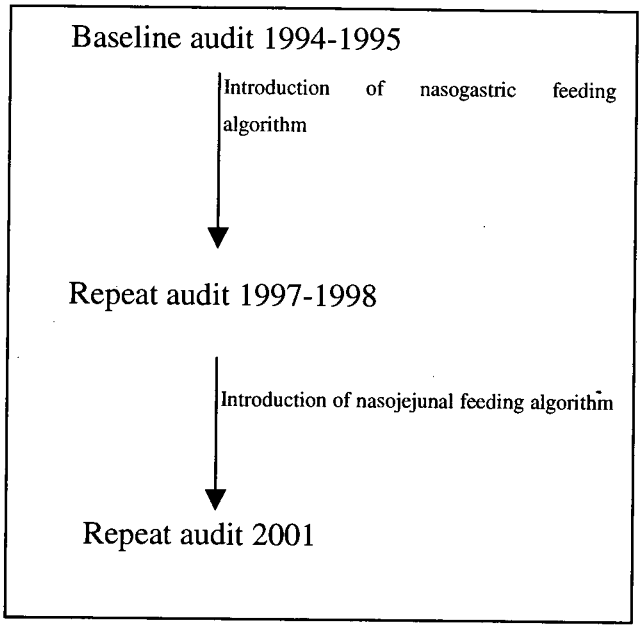

Figure 1: An overview of the auditing process

While each audit was evaluated at the time it was carried out, and any necessary changes implemented, the effect of the whole process of audit and development of clinical guidelines (i.e. clinical governance) on nutritional practice in the unit has never been evaluated before.

The aim of the study was, therefore to determine the impact of ongoing audit and clinical guideline development on nutritional practices in St.Mary's PICU. This retrospective analysis of the impact of continuous auditing on nutrition support would enable the local observers to monitor the effect auditing has had on the route of feeding, the energy delivered and the time it has taken to initiate feeding. The results of the study can be of significant use to other PICU's and provide a model of good feeding and nutritional practices.

CHAPTER 2: BACKGROUND TO NUTRITION IN THE CRITICALLY ILL CHILD

2.1 CRITICAL ILLNESS AND NUTRITION

Traditionally nutritional support has been withheld in the CIC until metabolic and cardiopulmonary stability has been established. The question is, how is metabolic and cardiopulmonary stability assessed and how does it affect nutrition? In order to provide appropriate nutritional support in a PICU, the above principles and the subsequent effect on nutritional status need to be understood.

Critical illness is characterised by a cascade of endocrine and metabolic reactions, affecting all major organs, including the gastrointestinal tract (GIT). In addition to the physiological process triggered by stress, gastrointestinal motility has been shown to be affected in mechanically ventilated patients, which might be attributed to the necessary life-saving medication administered during the admission (e.g. morphine, antibiotics), as well as the disease process itself. The inotropic agents (i.e. adrenalin) have been shown to affect peristalsis; epinephrine having the greatest inhibitory effect and dobutamine the least [24, 25.] Clinical manifestations of the above include gastrointestinal intolerance of enteral nutrition (impaired digestive enzyme secretion, decreased motility, cholestasis, increased intestinal permeability) [26], increased risk of gastroesophageal refluxing, constipation or diarrhoea and mechanical ileus [27]. In addition, provision of nutrition to the critically ill paediatric patient is complicated by a lack of reliable access for feeding, poor guidance on the monitoring of feed tolerance and the interruption of feed for procedures[28].

2.1.1 ACUTE STRESS AND SUBSTRATE MOBILISATION

Understanding the underlying substrate metabolism during the acute phase response explains various unique aspects of nutrition in a PICU. During physiological stress, such as major burns, trauma, complicated surgery, severe infection or inflammation, a complex physiological response is initiated. It is characterised by a fluid shift from the intracellular, to the extracellular compartments, tachycardia, high cardiac output, increased pulmonary ventilation, pyrexia as well as extensive endocrine and metabolic alterations [29].

This reaction of the body to physiological stress is not a static process and changes over time. The acute phase response to this can be divided into 2 phases: the ebb phase, which starts during the first few hours after injury and lasts for only 24-36 hours, is characterised by the body's attempt to maintain normal perfusion and mobilisation of stress hormones. The flow phase is the dynamic state of acute injury and affects substrate metabolism. It may last for days, weeks or months depending on the underlying diagnosis. The final phase -the anabolic phase- is characterised by the slow re-accumulation of protein and body fat after the metabolic response to injury subsides. (Figure 2 and Table 1)

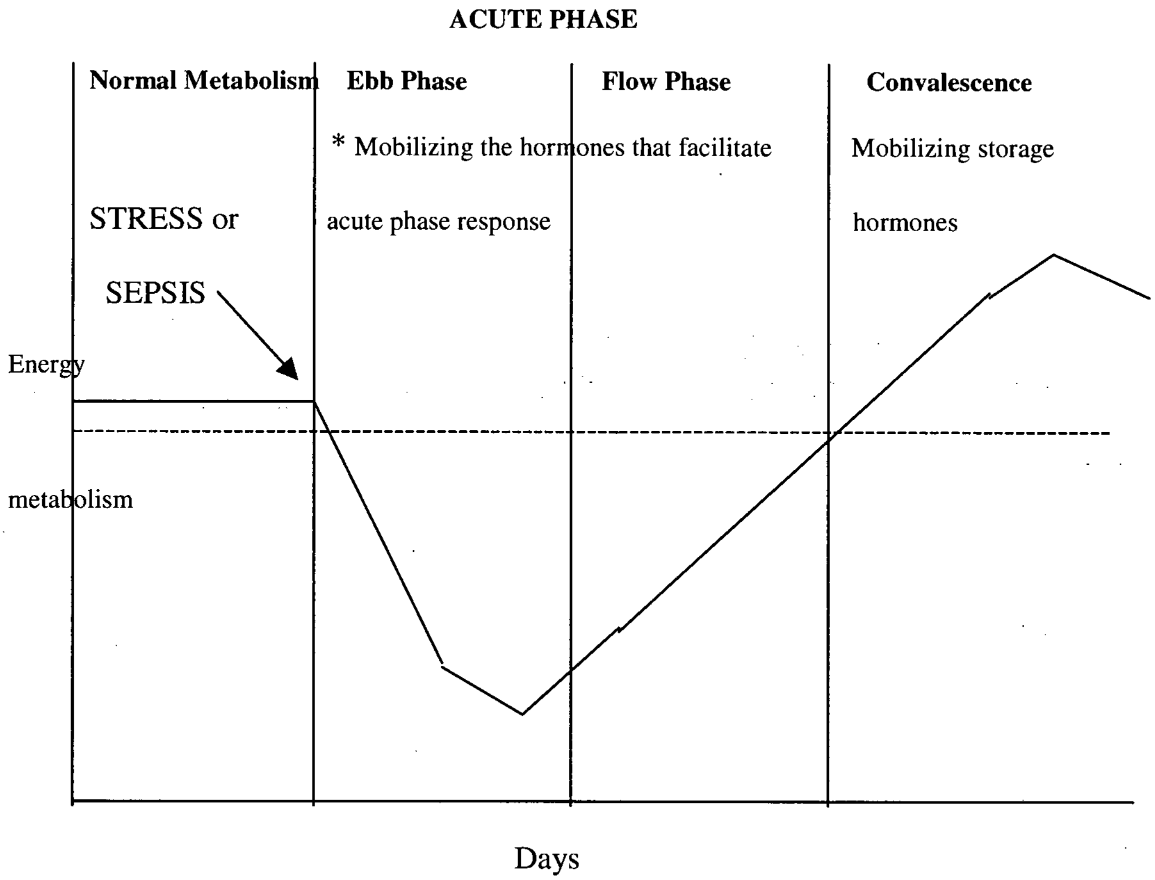

Figure 2: Energy metabolism during the response to stress

Source: Meyer et al 2002 [29]

* Catecholamines, corticosteroids, glucagons, growth hormones, injury hormones, insulin

Table 1: Metabolic Changes during the Ebb and Flow Phases in Response to Injury and Critical Illness

	Ebb Phase	**Flow Phase**
Cardiac Output	* ↓	↑
Oxygen Consumption	↓	↑
Body Temperature	↓	↑
Nitrogen Loss	-	↑
Blood Glucose	↑	↑
Glucose Production	-	↑
Lactate	↑	-
Free Fatty Acids	↑	↑
Insulin	↓	↑
Catecholamines, Glucagons, Cortisol	↑	↑
Insulin Resistance	↑	↑
Cytokine Production, Tumour Necrosis Factor	-	↑

* ↑ = increased ↓ = decreased

Source: www.mcmahonmed.com [30]

The endocrine response to stress is mediated through the release of catecholamines, growth hormones, adrenocorticotropic hormone (cortisol and glucagon) in conjunction with the cytokines interleukin-I (IL-I) and tumour necrosis factor (TNF).

These mobilising hormones in turn activate the metabolic alterations characterised by acute stress: protein, fat and glycogen catabolism which provide additional energy for altered requirements [30]. Increased carbohydrate requirements are provided by increased rates of glycogenolysis and gluconeogenesis to provide adenosine triphosphate (ATP). Similarly ß-oxidation of fatty acids have a dual function in that it provides acetyl coenzyme A (CoA) and malonyl CoA for entry into the Krebs cycle. Fats can also be converted to ketone bodies, acetoacetate, ß-hydroxybutyrate and acetone. These can be metabolized to form acetyl CoA for entry into the tricarboxylic acid (TCA) cycle. However ketone production is not a feature of the acute phase response [30, 31].

In adults, the hallmark of the stress response is protein catabolism which is characterised by increased urinary nitrogen, muscle wasting and net anabolism of visceral tissues (liver and immune system)[30] . Amino acids can serve as a precursor for acetyl CoA, enter the TCA cycle and provide a substrate for hepatic and renal gluconeogenesis [31]. In addition protein from the viscera, skin collagen and secretory proteins (albumin) are mobilized to produce proteins that are particular important to surviving the injury [30].

A recent study by Coss-Bu et al[32] focused on the relation between a critically ill child's metabolic state, their nutritional intake, substrate utilization and nitrogen balance. This study suggests that critical illness is associated with hypermetabolism. Several other studies exist, contradicting the above, suggesting that critically illness in the paediatric population is not related to a hypermetabolic state [33]. This has been demonstrated by a recent study investigating energy metabolism in infants and children with systemic inflammatory response syndrome (SIRS) and sepsis. The energy requirements of these children were not found to be increased. The authors speculated that these children diverted the energy for growth into the recovery processes [21]. However, both the study from Coss-Bu et al and Turi et al, found that, unlike the critically ill adult, where the stress response is characterised by protein catabolism, in critically ill children fat is used preferentially for oxidation and carbohydrates are poorly utilised [21,32]. Although the verdict on energy metabolism per se is still pending, it is clear that substrate metabolism needs to be taken into account when calculating the energy requirements for CIC and choosing either EN or PN.

2.1.2 THE EFFECT OF CRITICAL ILLNESS ON THE GASTROINESTINAL TRACT

The notion that the GIT exerts a powerful, influence on the pathogenesis of human illness has been a recurring and particularly tenacious theme in medical history. The Egyptians 4,000 yrs ago speculated that the gut was the locus of a disease-producing force [24.] At the turn of this century, Eli Metchnikoff, the father of cellular immunology, put forward his controversial views that bacteria from the intestine were responsible for a diverse group of disorders ranging from puerperal fever to old age and premature senility, earning him the scorn of a British playwright. He did however have a significant influence on his contemporaries in the areas of physiology, pathology, internal medicine, surgery, and gynaecology [24]. Like many great physicians before him, his theories have been verified in recent years.

Conventional management of critically ill patients has placed emphasis on stabilising and maintaining the circulation, respiration and renal function. The important role of the GIT has only been recognised in recent years.

Blood flow to the gut is affected during acute stress, by a complex interaction between the autonomic nervous system, hormonal factors and local mediators. The autonomic effect is mediated mainly through adrenergic supply to the smooth muscles of pre-capillary resistance vessels and vasoconstriction of post-capillary vessels. Hormonal factors like angiotensin and vasopressin and other local mediators such as prostaglandin, leukotrienes and thromboxane have more complex mechanisms, with many of them causing splanchic vasoconstriction. Research indicates that during haemorrhagic shock, oxygen delivery to the gut can decrease to as little as 30% of the initial value, whilst oxygen consumption remains unchanged [26]. Resuscitation aims to restore splanchic reperfusion, but controversy exists as to the extent to which blood flow to this area is restored during reperfusion [26, 34]. The severity of reperfusion injury ranges from:

1. Increased capillary permeability
2. Increased mucosal permeability
3. Superficial injury to the mucosa
4. Transmucosal injury
5. Full thickness injury of the bowel wall

Thus lifting of the epithelial cells at the tip of the villi represents minimal damage and as ischaemia becomes more severe or prolonged, epithelial cells are lost from the sides of the villi until the villus core is exposed and disintegrates. Damage to the gut is only significant at stage 3 and is greater after partial than total gut ischaemia.

Ischaemic injury of sufficient severity to cause injury to deeper parts of the gut wall will be such that no additional damage can occur on reperfusion. Structural damage caused by reperfusion manifests itself in impaired nutrient absorption, increased gut permeability, decreased bowel motility and the translocation of bacteria associated with an increase in line infections [26]. (Figure 3)

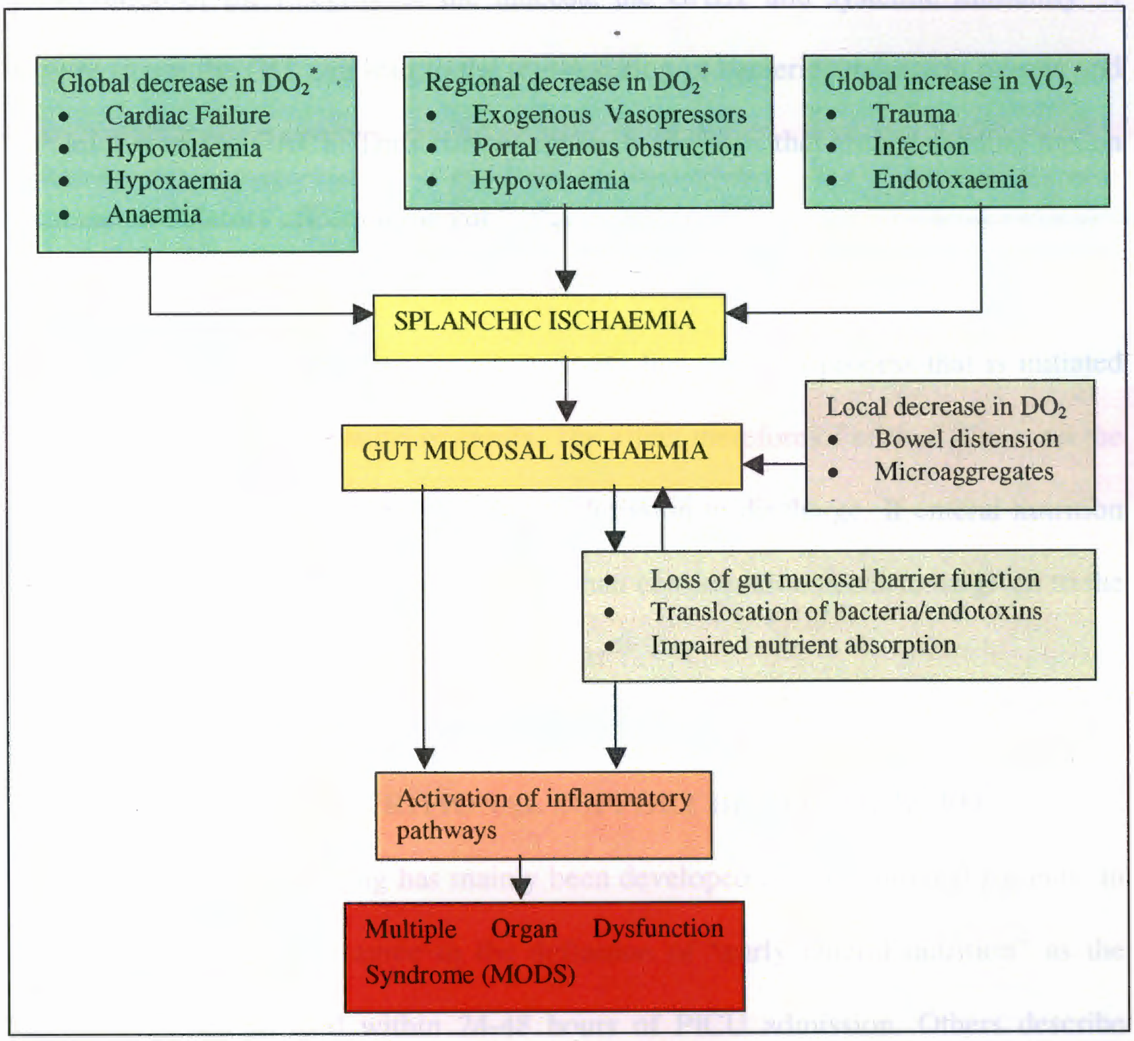

Figure 3: Summary of the current hypothesis of the role of gut mucosal hypoperfusion in the pathogenesis of MODS

Source: Dobb 1996 [26]

* DO_2 = Delivered Oxygen VO_2= Oxygen Volume

Closely linked to gut mucosal hypoperfusion is the immune function of the gut during critical illness. Gut associated lymphoid tissue (GALT) plays an important role in mucosal immunity, mounting a response to both infections and residential bacteria [34]. Studies comparing EN to PN have demonstrated in the majority of cases a significantly lower rate of complications when feeding into the gut, due to the preservation of the integrity of the mucosa, the GALT and systemic immunity [34]. Failure to use the GIT can lead to the translocation of bacteria, endotoxin release and breakdown of the GALT. Thus current research confirms that enteral feeding has an immune modulatory effect on the gut [34, 35].

The hormonal and metabolic response to stress however is a process that is initiated immediately, following trauma or sepsis. The affect therefore of critical illness on the GIT needs to be taken into account from admission to discharge. If enteral nutrition has an effect on gut immunity and motility then consideration needs to be given to the ideal timing of initiation of nutritional support [36].

2.2 WHEN SHOULD NUTRITIONAL SUPPORT BE COMMENCED

The concept of early feeding has mainly been developed in adult surgical patients. In paediatrics most authors agree to the definition of “early enteral nutrition” as the initiation of enteral feed within 24-48 hours of PICU admission. Others describe patients receiving immediate feeding, but unfortunately this term does not come with a clear definition [36].

Four main hypotheses could justify the use of early feed in critically ill patients:

- Fasting has a deleterious effect on these patients

- Energy supply plays an important role in the promotion of energy metabolism
- The delivery of nutrients is important for gut maintenance
- Specific nutrients provide support for organ and system functions [35]

A pilot study by Chellis et al[27] showed an average delay to initiate any nutritional support in paediatric intensive care [both Parenteral (PN) and Enteral Nutrition (EN)], of 3.1 days to initiate nutritional support and 6.5 days to achieve target energy requirements. A similar study on 100 children admitted to a PICU, indicated that the median number of days before initiation of nutritional support was 2 days [25]. It therefore comes as no surprise that a study by Pollack et al [8] showed a prevalence of significant protein energy malnutrition in 16-20% of all children within 48 hours of admission to PICU [4]. This study assessed acute protein and energy depletion by using the Waterlow classification for malnutrition and triceps skinfold thickness to judge fat percentage. Although this study was carried out in the eighties, it is still considered relevant to the current situation in PICU's [4].

Chellis et al also showed that early enteral feeding in CIC, starting at 5-10 ml per hour and increasing the rate in order to meet full energy requirements within the first 24 hours was well tolerated by 74% of the patients, the remaining 26% reached their requirements within 48 hours [27]. It is of note that several of these patients were fed in spite of not having bowel sound as bowel sounds are now considered to be an unreliable indicator of feed tolerance and absorption [27].

Briassoulis et al used a feeding protocol, promoting early intragastric feeding (within the first 12 hours of admission) in CIC [37]. Energy requirements were based on predicted basal metabolic rate (PBMR), assuming that mean PICU admission is 5 days and energy requirements mimic the ebb and flow phase, previously discussed. The protocol aimed to provide; 50% (day 1), 100% (day 2), 125% (day 3), 150% (day 4) and 100% (day 5) of PBMR, using a 1kcal/ml full strength enteral formula. Energy intake was thereby aimed at meeting the patient's PBMR on the second day of critical illness and exceeding that by 50% by day 4, while the patient remained in stress. Success rate (approaching PBMR by day 2) for early EN was 94.4% in this study. The higher success rate found by Briassoulis et al could be attributed to the slower start-up regime (50% of PBMR by day 1 and 100% by day 2), contrary to Chellis et al, aiming for 100% of energy requirements by day 1, with a significantly lower success rate (74%) [4,27,37]. In 2002, Briassoulis and colleagues elaborated further on the impact of early enteral nutrition (utilizing the same early enteral feeding protocol as above) by using the same data set to assess the impact on nitrogen balance in CIC. This data suggests that using an aggressive early enteral nutrition protocol, improves nitrogen balance in the acute phase in 75% of CIC. Thus early enteral feeding is not only feasible but of nutritional benefit to this subset of patients [38].

Concerns have been raised on this new practice of early enteral feeding. A study in adults' randomised patients into either early EN, defined as receiving 100% of requirements on day 1, or late EN, defined as receiving 20% of requirements on day 1[39]. Patients in the early feeding group had statistically greater incidence of ventilator-associated pneumonia and diarrhoea attributed to *C.difficile*, when compared to the late feeding group. The early group also had a longer duration of mechanical ventilation and number of antibiotic days. The adverse effect of early enteral nutrition in this specific trial can most probably be attributed to the extremely aggressive initiation and progression to full EN (100% of energy requirements by day 1). Further concerns have been raised regarding early enteral nutrition, by a recent study on adults, which has focused on the impact of early enteral nutrition in mechanically ventilated patients in the prone position, which has increasingly been used due to the positive effect it has on ventilatory support. Early enteral feeding in this patient group was associated with a higher rate of vomiting and residual gastric volumes, which could lead to a higher incidence of pneumonia [40]. The adverse effect of early enteral nutrition in this study is most probably related to the positioning of the patient, rather than the initiation of early enteral feeding support.

A meta-analysis by Marik et al compared early (defined as initiation of feeds in 36 hours) against late EN [41]. All randomized controlled trials that compared late, versus early EN in hospitalised adult post-operative, trauma, head-injured burn and medical intensive care unit patients, were included in this study. These studies were compared for rates of infection, non-infectious complications, length of hospital stay and mortality. Contrary to data from Ibrahim et al[39], the authors showed that there were significantly lower rates of infection and lengths of hospital stay in the early nutrition group, but no differences were observed between the groups with respect to non-infectious complications or mortality [41, 42]. It can be concluded from the above studies, that the success and safety of early enteral nutrition depends not only on when feeding is commenced, but also, the positioning of the patient and more importantly how aggressive feeding support is. Rapid progression to full enteral nutrition has been associated with poor feed tolerance and other complications: increased rate of pneumonia, vomiting and diarrhoea. The success rate seems to be higher, in those regimes starting early, but increasing the feeding rate over 48, instead of 24 hours [35]. The above data implies, that early enteral nutrition is safe and of benefit to the patient [23, 40]. Once the decision has been made to initiate nutritional support, the most appropriate route of feeding has to be considered for the patient, taking the underlying diagnosis, current medical condition and nutritional status into account.

2.3 ROUTE OF FEEDING IN CRITICALLY ILL CHILDREN

The pros and cons of enteral (gastric and postpyloric) versus parenteral feeding have been a point of debate for some time. The balance of evidence favours enteral feeding and it is now accepted as the preferred route for nutritional support, largely due to the proliferation of evidence suggesting that enteral feeding is associated with reduced morbidity, complication and costs, compared with PN [42] .The move away from PN is undoubtedly justified because many patients were fed parenterally in the past despite having a fully functional GIT. However, concern has been expressed that blind faith is placed in the benefits of EN, disregarding its risks and in many occasions at the cost of adequate delivery of energy [43]. The question that needs to be answered by every clinician is, "does PN increase the risk to my patient, without any added benefit?" Every decision taken in medical or nutritional therapy should require consideration of the risks as well as the benefits. Over the years the negative press PN has received has led to the continued evolution in content, technique and clinical approach. For patients with failure of the gastrointestinal tract, PN provides a life-saving alternative. It is well known that patients in this setting receive suboptimal energy due to a variety of barriers related to both the enteral (tube placement, gastric aspirates) and parenteral route (line insertion, infection). The overriding question to be asked therefore is whether the CIC is being fed or not as failure to provide any form of nutritional support carries the highest risk [44].

The issue of delivery problems and the risk of aspiration are central to any discussion over EN and PN. Gastric delivery of enteral feed is frequently poorly tolerated due to disordered gastric motility which may lead to aspiration. Therefore interest has focused on postpyloric feeding. Nasojejunal (NJ) feeding has been shown by several centres to be safe and effective in this subset of patients, enabling adequate delivery of energy in a shorter period of time, reducing the incidence of hyperglycaemia and hypertriglyceridaemia and maintaining normal hepatic function both associated with PN [45, 46, 47] .In addition a recent study in children has shown that postpyloric feeding can safely be continued even during ventilatory weaning and tracheal extubation. This enables the child to be fed up to extubation, without loosing any feeding time, whilst waiting for gastric emptying to take place [48]. However, many units have avoided post pyloric feeding, as NJ tubes are notoriously difficult to place and get dislodged very easily [49].

Several successful blind placement methods have been developed to facilitate bed-side placement, with a placement success rate between 93-99% [49]. A blind placement technique was developed combining several well-known methods with a new polyurethane unweighted feeding tube with flexible stylet (Nutricia 6,8,10 F: 90cm and 110 cm), following an audit in the PICU of St.Mary's Hospital London. This method was tested on 50 patients in the intensive care unit; time of placement and complications were documented and placement was confirmed with the suggested blue dye method as well as an abdominal X-ray. Fourty-eight tubes were successfully placed, judged by both the blue dye and X-ray confirmatory techniques. The mean tube placement time, was 25 minutes[50]. During the audit in 2001 the success of this placement method was assessed, confirming placement success rate of 95-96%[51]. (Appendix C)

Once the route of feeding has been secured, then the next topic of concern can be addressed: what are the energy requirements of CIC?

2.4 ENERGY REQUIREMENTS IN CRITICALLY ILL CHILDREN

Nutrition in paediatric patients consists of supplying both fluids and nutrients whilst taking the child's ongoing needs for growth and organ development into consideration [3]. A study by Turi et al on metabolism in CIC showed that infants and young children with Systemic Inflammatory Response Syndrome (SIRS) unlike adults, are not hypermetabolic, and therefore do not require a higher energy intake has been confirmed by several trials investigating the energy expenditure in CIC [21] . It has been hypothesised that energy requirements are lower than expected, due to a decrease in brain activity as a result of ventilatory support and sedatives, reduced insensible losses as result of a thermoneutral environment, the provision of humidified respiratory gases and the impediments of growth during critical illness [4, 52].

Predictive formulae currently available include the Harris-Benedict [53] the Food and Agriculture Organization/World Health Organization/United Nations University, Talbot, Schofield [54] and PICU regression equation [52]. The use of any of these equations to predict BMR, in the paediatric critical care setting, can introduce error as they rely on accurate weight measurements, which is very difficult to obtain in a

PICU [55]. They also require the addition of a stress and activity factors, which is dependant on the subjective opinion of a dietitian or clinician (Table 2)[56].

Table 2: Predictive Equations for Calculating BMR in CIC

Name of Equation	Equation (kcal/24 hours)
Harris-Benedict	Infant 22.10 + (31.05 x W) + (11.6 x H) Males 66.437 + (13.7516 x W) + (500.33 x H) – (6.755 x A) Females 655.0955 + (9.5634 x W) + (184.96 x H) – (6.755 x A)
World Health Organization	Males 0-3 y: (60.9 x W) - 54 3-10 y: (22.7 x W) - 495 10-18 y: (17.5 x W) + 651 Females 0-3 y: (61 x W) -51 3-10 y: (22.5 x W) + 485.9 10-18 y: (17.686 x W) + 658.2
Schofield (weight)	Males <3 y : (59.512 x W) – 30.4 3-10 y: (22.7 x W) + 504.3 10-18 y: (17.5 x W) + 651 Females < 3 y: (58.317 x W) – 31.1 3-10 y: (22.706 x W) + 485.9 10-18 y: (17.686 x W) + 692.6
Schofield (weight and height)	Males < 3 y: 0.167W + 1517.4H -616.6 3-10 y: 19.59W + 130.3H + 414.9 10-18 y: 16.25W + 137.2H + 515.5 Females < 3 y: 16.252W + 1023.3H – 413.5 3-10 y: 16.969W + 161.8H + 371.2 10-18 y: 8.365W + 465H + 200.0 >18 y: 13.623W + 283.0H + 98.2

W = weight in kilogram, H = height in metres, A = age

Source: Hardy et al [53]

The above equations are derived from indirect calorimetry in mostly in healthy adults and some including children with correction factors for metabolic stress [52, 53, 55]. Studies have shown that most predictive formulas grossly overestimate energy requirements, except for the regression equation recently developed by White and colleagues, which significantly underestimates requirements according to Martinez et al[57]. Previously it was thought that neuromuscular blockade, inotropic support and the diagnosis itself, would influence energy expenditure in CIC, but both Briassoulis et al and Taylor et al [55] have reviewed the energy expenditure of sepsis, brain injury, respiratory failure, transplant, post-operative cardiac surgery and head injury, liver transplantation, acute liver failure, post-neurosurgery, septicaemia, respiratory failure and hypothermia respectively. No significant difference was found between patients in these groups [4, 55]. (See Figure 4)

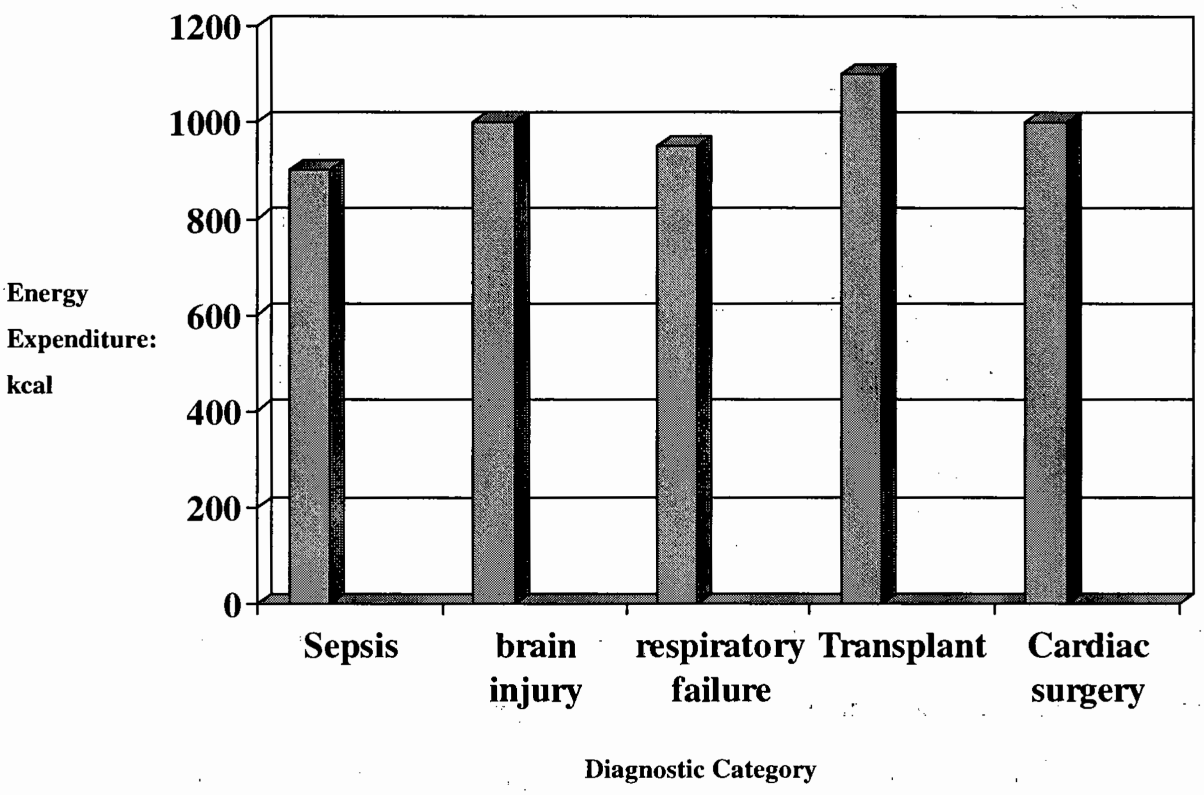

Figure 4: Comparison of energy expenditure in different diagnostic categories

Source: Taylor et al [55]

Most authors have found that the actual energy expenditure is closer to the BMR[4, 55,] which implies that current equations have lead to the overfeeding of many of these patients which in turn may have affected their outcome[7]. Further limitation to the use of predictive equations is their dependency on an accurate admission weight. PICU admissions are rarely planned; most children arrive in the unit as emergency cases. Resuscitation includes the provision of intravenous fluid (IV), which can be up to 150ml per kg. Although the latter is undoubtedly life-saving, it often leads to severe oedema and ascites, which makes weighing extremely difficult and inaccurate. Weight is, therefore estimated, the most common method being the Broselow tape, which is based on the length of the child[59].

The suggested method for estimating energy requirements is the routine use of indirect calorimetry, which has its limitations in that its accuracy is poor in patients with an inspired F_{IO2} >60%, an air leak of more than 10% around the endotracheal tube and patients who have nutrient losses during haemofiltration[4,52,59]. Most intensive care units do not have access to this equipment and its determination is time consuming and needs to be repeated daily.

The EAR is an estimate of the average requirement for energy and other nutrients. Approximately 50% of a group of people will be requiring less, and 50% requiring more energy or nutrients than the EAR. The EAR for energy is based on the BMR and activity factor for the present population of the United Kingdom[60]. It has been estimated that 30 % of the EAR for energy is being utilized for growth and activity, therefore the remaining 70% is thought to be equivalent to the BMR[4]. (Appendix D) The EAR for energy is by no means ideal for the patients in a PICU, but they provide a useful alternative in the auditing process as it is not dependent on an accurate weight, but rather on age. In summary, the three key elements that are critical in the provision of nutritional support in CIC are:

- route of feeding
- initiation of nutritional support
- provision of sufficient energy to meet predicted energy requirements.

This remains an area in nutrition where the challenge of successful alimentation will continue to occupy dietetic and medical time and effort. This study attempts to shed some light on this extremely complex area of nutrition, and how an implemented auditing process in combination with existing research can improve feeding practices in every PICU.

CHAPTER 3: METHODOLOGY

3.1 SUBJECTS

The PICU at St.Mary's hospital, where data collection took place, admits an average of 550 infants and children per annum, between the ages 0-16 years, of a variety of ethnic background. It is the referral centre for life threatening infections from the South-East of England, but depending on bed-space, paediatric patients with any other diagnoses (i.e. post-surgery, trauma, post bone marrow transplant) are admitted to the unit. The PICU has a unique clinical team, which accepts referrals from other hospitals, taking over the patients' care from the moment of verbal referral until discharge from PICU.

Three prospective audits were carried out in October 1994-May 1995 (1994- 1995), August 1997-April 1998 (1997-1998) and February 2001-October 2001 (2001), assessing feeding practices in the PICU at St.Mary's Hospital.

The objectives for the analysis of this prospective audit were to determine whether the audit process and implementation of clinical guidelines has had any effect on:

1. time taken to initiate nutritional support
2. choice of the feeding route
3. percentage of children reaching 50% and 70% of EAR by day 3 of PICU admission
4. overall impact of the auditing cycle on current practices regarding the time taken to commence nutritional support, feeding route and EAR reached by day 3

3.1.1 ETHICS APPROVAL

The NHS does not require Research and Ethics Committee approval for the auditing of current practices. Nevertheless, for the purpose of this retrospective analysis Ethics approval was obtained from the Human Research Committee of Stellenbosch University (Ethics Reference Code N04/04/072)

3.2 DATA COLLECTION

The same inclusion criteria were used for the three audits: all patients admitted for more than a complete 24 hour period (including weekends), defined by the units' daily fluid charts were included in the audit, independent of the route of feeding. The units' fluid charts represented a PICU day: from 08h00 until 08h00 the next morning. Information on the type of enteral or parenteral feeding formula for each patient was obtained from the dietitians', nutritional information sheet, which was tailored towards each patient's energy requirements. Data was collected until discharge or a maximum of 10 days (whichever came earlier). The only patients who were excluded from the audit were those who were admitted for less than 24 hours.

Data was collected by the paediatric dietitian, who was designated to the PICU. The audit in 1994-1995 (7 month period) was performed by a different dietitian to the audit in 1997-1998 (8 months) and 2001 (8 months), which were both performed by the author of the thesis. In addition, a PICU research nurse assisted during the 2001 audit. The nurse received training on data collection from the dietitian, to ensure that the process was uniform. All data assembled by the research nurse was examined, by the dietitian on two occasions; after collection and when data was entered onto the computer data base, for errors in calculations of daily delivery of energy and incomplete data. Any incomplete or unclear data was discarded when information was entered onto the computer system. A total number of 16 patients' data were discarded (missing data n = 11, illegible data n = 5) from the data analysis process: 7 sets of data from the 1994-1995, 8 from the 1997-1998 and 1 from the 2001 audit period. Medical notes were requested to verify the data that was collected in all three audits. More data was discarded from 1994-1995 and 1997-1998 due to the original medical notes not being found or documentation being imprecise. The data collection sheet was identical for each audit. The use of the same data collection sheet for all three audits, was possible, in spite of the introduction of feeding protocols, because the outcome markers (time taken for nutritional support to be initiated, route of feeding and percentage of EAR reached) did not change during the auditing process (Appendix B). Recording of data started the same hour a patient arrived on the unit, excluding the retrieval period. This coincided with the nursing documentation on the units' fluid charts. Data collection took place daily, except for weekends, after 08h00, which signified a completed PICU day. Weekend data was collected on a Monday after 08h00 for all patients admitted over this period. All the fluid charts were filed into the patient's medical records, which were kept on the unit for 7 days post PICU discharge. This allowed both the dietitian and the research nurse to record data even if a patient had been discharged from PICU prior to data collection being completed. Day one data was usually incomplete, as defined by our daily fluid charts, due to the variations in admission time. This data however was still included as it provided crucial information on the time it took for enteral feeding to be commenced as well as progression to full nutritional support.

The daily fluid balance charts and the dietetic feed information sheet contributed the following information: all IV fluids (PN, dextrose, antibiotics, sedation, human albumin, blood), enteral fluids (NJ and NG, additional water, probiotics in the form of fermented milk) and total output (bowel motions, urine, stoma losses, any losses from chest and peritoneal drains). Data for any IV fluids contributing to the energy requirements were included [IV medication diluted with dextrose, PN, dextrose maintenance fluids, Diprivan (also known as Propafol)] as well as all enteral fluids providing energy to the child. Route of alimentation was recorded, differentiating between NG, NJ and PN. Gastrostomy and jejunostomy feeding were classified under the NG and NJ route respectively. There seemed to be an increased trend in the number of patients fed via the gastrostomy and jejunostomy feeding route during the auditing years. Only one patient had a gastrostomy in 1994-1995 (zero jejunostomy feeding) and in 2001, 5 patients had a gastrostomy and 1 patient had jejunostomy feeding. The enteral feeding formula used for each child was recorded to enable calculating the energy delivered. No additional biochemical, radiological or invasive procedures were required for data collection.

The same patient demographic data and patient characteristics (i.e. weight, diagnosis) were recorded in all three audits. The demographic data included: age and gender of the child. The age was rounded off in infants below 1 year of age to the nearest month (i.e. 5 ½ month old baby was rounded off the 6 months) and children above 1 year to the nearest completed year (i.e. 6 ½ year old child was rounded off to 7 years). This was done to enable the comparison with the EAR for energy for each age group (Appendix D).

The weight documented on admission was either accurate or estimated, based on the Broselow measuring tape, which provides an estimated weight for the measured supine length[58]. The estimated weight was only used in cases where accurate weight was not available.

Data on the specific medical diagnoses of patients was also collected (Table 4). These were then categorised according to diagnostic groups: respiratory (i.e. bronchiolitis, pneumonia, status asthmaticus), sepsis (i.e. meningoccocal sepsis, Human Immunodeficiency Virus), neurology (i.e. trauma to the head, non-accidental injury), surgery (i.e.Nissans fundoplication, appendicitis) and other (i.e. metabolic diseases, unknown diagnosis).

Table 4: Summary of data collected for each audit

Weight (estimated or accurate)
Diagnosis
Time of admission
Time nutritional support commenced
Route of feeding (NG, NJ or PN)
Enteral nutrition formula
Energy provided by EN (included NG and NJ)
Energy from IV nutrition (including 5-10% Dextrose)
Day and time of discharge

3.3 DATA ANALYSIS

Data analysis was performed with Analyse-It General 1.62 statistical software. Patients from all three audits were not matched (diagnostic category and severity of disease) for data analysis. The time taken to initiate nutritional support was analysed using the Kruskal- Wallis ANOVA test. The Chi-Square test was used to analyse the statistical significance of both the proportions of feeding routes across the years as well as the number of patients receiving 50% and 70% of the EAR of energy.

CHAPTER 4: RESULTS

Data analysis of 255 eligible patients for the three audits was performed. The number of patients enrolled in each audit respectively was 83 in 1994-1995, 72 in 1997-1998 and 100 in 2001 (Table 4).

Patient gender was similar in all three audits, but for the purposes of data analysis, gender was not taken into account, only the total number of patient enrolled during each audit. The mean age of all patients included in the audits was similar: 3.5 years in 1994-1995, 3.2 years in 1997-1998 and 3.3 years in 2001 (Table 4).

The patients from each audit were classified according to the diagnostic categories. This however does not provide an indication of the severity of disease. A more reliable marker of severity would have been the Paediatric Risk of Mortality (PRISM) score; however this data was not recorded and was therefore not used for the purpose of the audits.

Diagnostic categories were therefore simply used to confirm that the general trend in diagnoses had not changed significantly over the period of the three audits. For the duration of the three audits the diagnostic profile did not change, with respiratory and sepsis related illnesses remaining the most common diagnoses in the PICU.

Table 4: Demographic data and patients characteristics

	1994-1995	1997-1998	2001
Number of patients (n)	83	72	100
Diagnostic categories of patients:			
Neurology	5	5	11
Respiratory*	30	32	42
Surgery	2	1	7
Sepsis*	32	25	32
Other	14	9	8
Gender of patients enrolled in the audit	39 male 44 female	40 male 32 female	44 male 56 female
Mean age of patients in years	3.5	3.2	3.3
Standard Deviation	SD 4.3 years	SD 4.2 years	SD 4.3 years
Age range	(birth-12.5)	(birth-14)	(birth-12.7)

* The most common diagnostic categories during the auditing period

4.1 TIME TAKEN TO INITIATE NUTRITIONAL SUPPORT

The median time taken to initiate nutritional support from admission was assessed with the Kruskal-Wallis test (ANOVA). The median time to initiate nutritional support during the baseline audit in 1994-1995 was 15 hours, which was reduced to 8 hours during the 1997-1998 and further reduced to 5.5 hours in the 2001 audit. The impact the auditing process had had on the initiation of nutritional support between the 1994-1995 and 2001 audit, is indicated by a significant reduction in time taken for nutrition support to commence. ($p<0.001$)* (Figure 5)

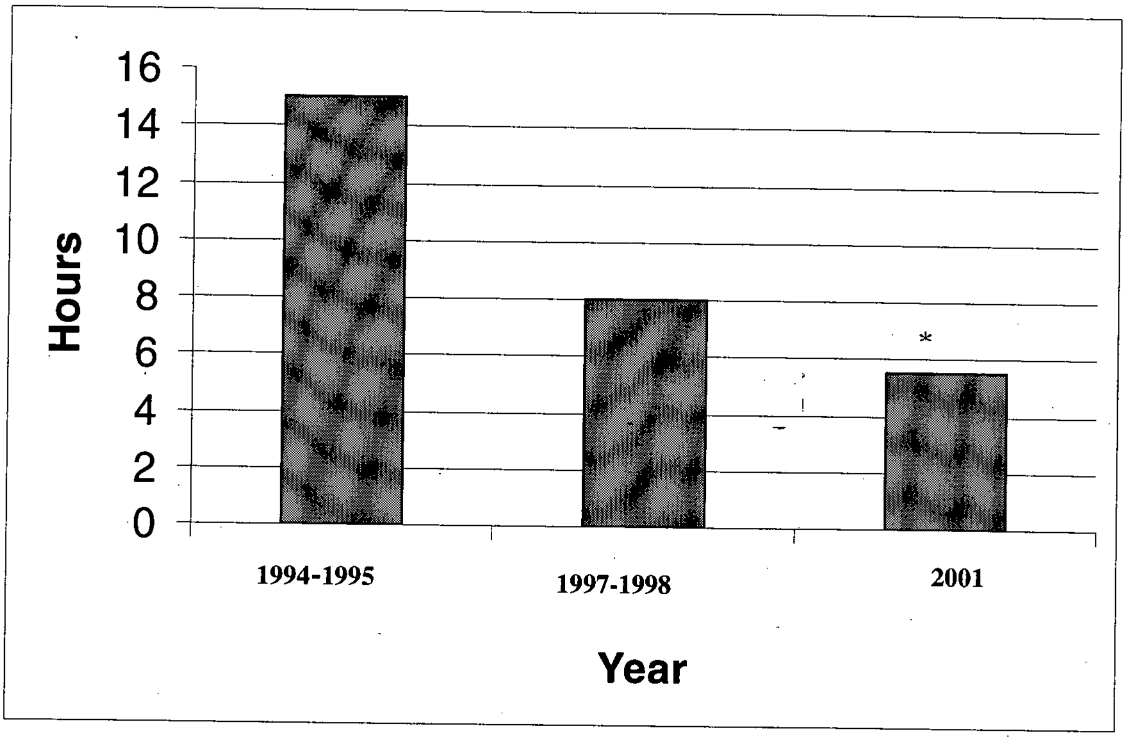

Figure 5: Median time taken for nutritional support to commence (* $p < 0.001$)

4.2 THE FEEDING ROUTE

The route of nutritional support was expressed as enteral (NG, NJ, gastrostomy and jejunostomy) or PN. The percentage of patients fed enterally (NG and NJ) in 1994-1995 was 89% (n = 72), which decreased to 80.8% (n = 49) in 1997-1998 and increased again in 2001 to 99% (n = 99). The parenteral route was used in 11% (n = 5) of the patients in 1994-1995, increasing to 19 % (n = 14) in 1997-1998 and decreased dramatically to 1% (n = 1) in 2001. The Chi-square test was used for comparing the proportions of the route of feeding between the 1994-1995 and 2001, comparing the enteral (divided into NG and NJ) with the parenteral route. There was a significant increase in the proportion of enterally fed patients between these audit periods. (Figure 6)

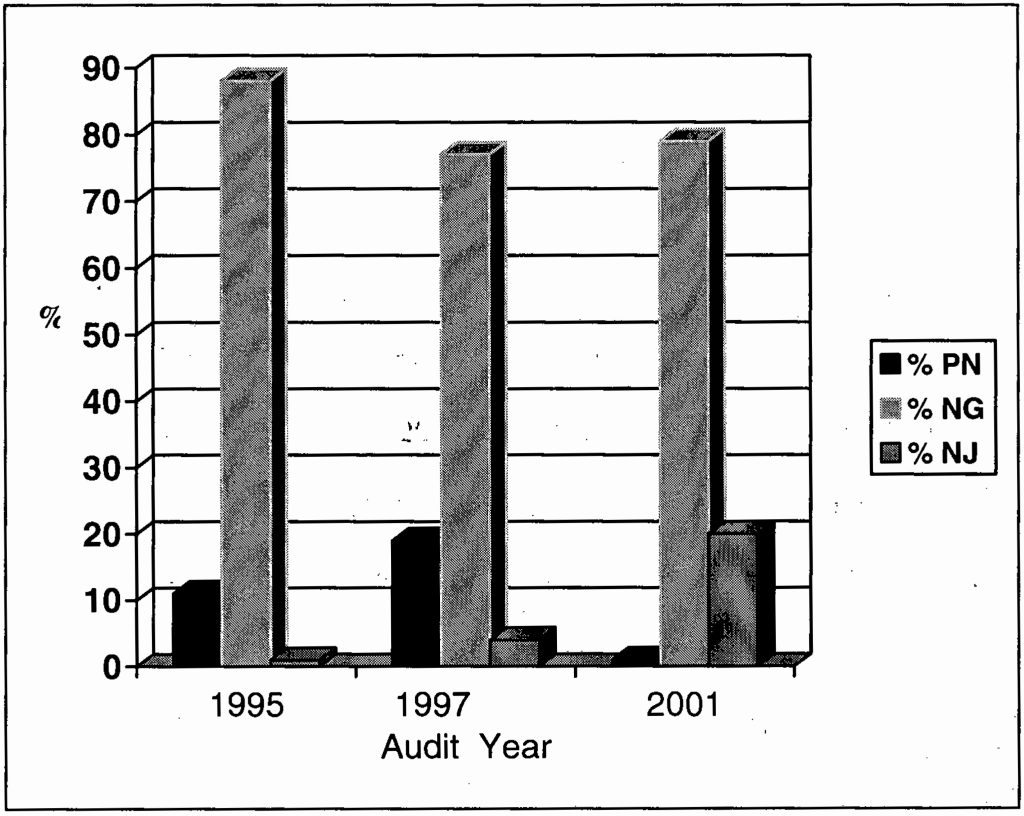

Figure 6: Comparison of feeding routes (1994-1995: PN = 11%, NG = 88%, NJ = 1%, 1997-1998: PN = 19%, NG = 77%, NJ = 4% and 2001: PN = 1%, NG = 79% and NJ = 20%)

4.3 ENERGY REQUIREMENTS REACHED

All children admitted to St.Mary's PICU received nutritional support via either the enteral or parenteral route, from the day of admission as part of their treatment (see section 4.1) Day three data was chosen to evaluate the percentage of EAR reached, as it was expected that most patients would have progressed to full nutritional support (either EN or PN) by day 3. Day 1 was considered unsuitable as it was the day nutritional support was customarily initiated via the NG route. Day 2 was also considered inappropriate for assessment, as it was the day when progression onto full nutritional support took place or the feeding route was changed to either NJ or PN due to perceived intolerance of NG feeding, judged by the units NG feeding algorithms.

By day 3 it was expected that most patients would have progressed to full nutritional support.

The data was categorised according to patients receiving more than 50% and 70% respectively of the EAR by day 3 of admission to the PICU. Children receiving more than 50% of the EAR rose from 18% (n = 15) in 1994-1995 to 36% (n = 26) in 1997-1998 and 58% (n = 58) in 2001. The Chi-square test was used to compare the percentage of EAR reached. The data from 1994-1995 was compared to 1997-1998 data (p = 0.028)* and the 1997-1998 data was compared to the 2001 audit data. (p = 0.2) The overall impact of the auditing process on the proportion of patients fed over 50% of the EAR for energy by day 3 was established by comparing 1994-1995 with 2001 data. A significant increase was seen in patients receiving more than 50% of the EAR over the audit periods. (p < 0.0001)*

The same was calculated for patients receiving more than 70% of EAR. In 1994-1995, 7% (n = 6) reached more than 70% this rose to 14% (n = 10) in 1997-1998 and 35% (n = 35) in 2001. Similarly the Chi-square test was used to compare the percentage or patients receiving more than 70% of EAR for energy by day 3. Data from 1994-1995 was compared to 1997-1998 data (P = 0.353) and 1997-1998 was compared to 2001 data. (p = 0.031)* The full impact the continuous auditing process had had on energy requirement was measured, by comparing 1994-1995 to 2001 data, which indicate a significant increase in patients reaching more than 70 % of EAR for energy by day 3. (p = 0.0008)* (Figure 7)

Although the area of energy expenditure in the critically ill child is still very debatable, the above data does suggest that regular auditing impacts favourably on the amount of provided: more provided in a shorter period of time.

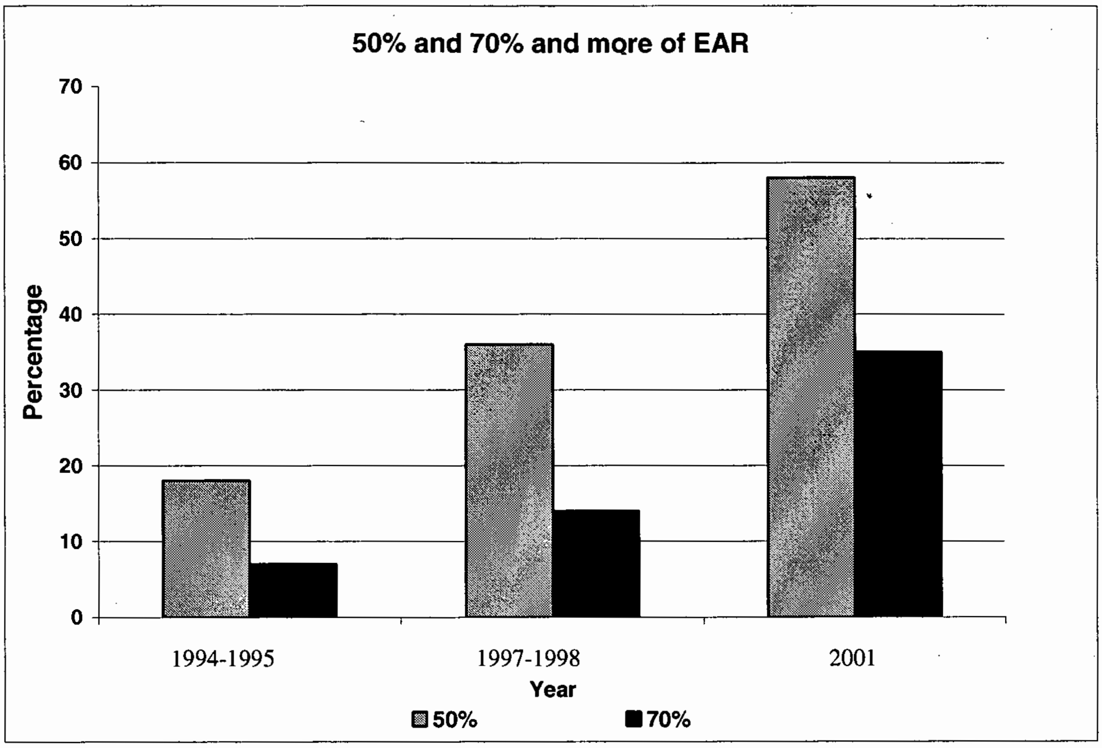

Figure 7: Percentage of patient receiving 50 % and 70% of EAR by day 3 in 1994-1995, 1997-1998 and 2001

CHAPTER 5: DISCUSSION

5.1 THE IMPACT OF THE AUDITING PROCESS

This retrospective analysis of three prospective audits on time taken to commence nutritional support, route of feeding and energy requirements achieved on a PICU, suggests that a continuous auditing process has a positive impact on feeding practices in CIC. Currently several one-off audits and surveys exist on nutritional practice in a PICU, but no published data is available on the impact of a continuous auditing process[25]. This longitudinal assessment of 3 prospective audits is therefore unique, in that it is the first published analysis of the impact the auditing process has on nutrition in CIC.

The key to the success of any audit is the implementation of strategies, which address the areas that have been identified as catalysts of poor nutritional status. The approach used by the nutritional team at St. Mary's PICU, was the introduction of a variety of feeding protocols in the form of easy to use algorithms. Several studies have highlighted the importance of written nutritional protocols (i.e. breastfeeding, route of feeding, transitional feeding, early feeding), which enable staff to make more objective decision on feeding manipulations[23]. Adam[61] has identified the four main areas that could benefit from a nutritional protocol: (1) patient selection, in which indications for feeding and evaluation of the risk/benefit ratio are discussed (nutritional screening); (2) timing of nutritional support, in which guidelines for initiating feeding are proposed; (3) delivery of nutrition, in which protocols to limit complications and optimize delivery are reviewed; and (4) feed content, in which guidelines for appropriate nutrients and formulations for special considerations are identified. The unit has a full time paediatric dietitian and therefore all patients have a full nutritional review within the first 24-48 hours of admission. Patients admitted over a weekend were reviewed early Monday morning (within 48 hours of admission). Protocols to identify children at risk of malnutrition (screening tool) were not necessary, as all patients on our PICU unit are automatically seen by the paediatric dietitian and no validated tool currently exists for this subset of patients. The feeding protocols introduced in this PICU were aimed at influencing the timing of introduction of nutritional support, the delivery of nutrition (route and rate) and the suitable feeds for each age group.

5.2 THE IMPACT ON THE TIMING OF NUTRITIONAL SUPPORT

Current data on the "ideal" time for initiation of enteral feeding in the CIC does not provide clinicians and health professionals with any clear guidelines, as described in Chapter 2. The baseline data from 1994-1995 pointed towards enteral feeding being initiated within 15 hours of admission. According to many authors this would still be classified as early enteral nutrition[61]. A decision was made to aim to reduce the time taken to commence nutritional support, because of an accumulating body of evidence that demonstrated beneficial effects of early EN on wound healing, gut mucosal integrity and a reduction of infectious complications [4, 41, 51]. Cummins et al, has found that early enteral feeding maintains (not restores) villous architecture, in contrast to PN, which causes more severe villous atrophy with crypt hypoplasia[63]. Early EN, according to Briassoulis, is tolerated by most CIC (86%), regardless of whether bowel sounds are present or not [23] .In addition, it has been suggested that early EN can even be safely administered for nutritional support in paediatric patients undergoing extracorporeal membrane oxygenation, which is well known for reducing splanchic blood flow, thereby increasing the risk of ischaemic gut damage [63, 64].

The audit data demonstrates that the time taken to commence nutritional support was successfully reduced from the initial 15 hours (1994-1995) to 8 hours in the 1997-1998 and 5.5 hours in the 2001. Initiating nutritional support within less than 6 hours of admission, through a straightforward auditing process and subsequent implementation of feeding protocols, was thought to be an accomplishment by the PICU. The challenge for the unit is to maintain this practice and aim to reduce the time to initiate nutritional support even further. Hart et al has studied the effects of aggressive early enteral nutrition on hypermetabolism and sepsis after severe burns in children.[65] Enteral support was initiated within 3 hours of admission on the burn unit. The authors concluded by strongly promoting aggressive nutritional support, as a delay in treatment may exacerbate catabolism, promote more extensive bacterial wound contamination, and likely increase the frequency of clinical sepsis. According to Hart et al this paradigm may also hold true for any critically ill patient suffering from catabolism as a result of extensive tissue trauma. It is clear however, that in order to verify this; more research in early aggressive feeding support in CIC needs to take place.[65]

It is likely that the introduction of NG and NJ feeding protocols (Appendix A) following the audits in 1994-1995 and 1997-1998 aided in decreasing the time taken to initiate nutritional support. Both sets of algorithms are age specific, providing information on how to initiate enteral nutrition, suitable feeds (all of which are kept in stock in the PICU) for all clinical settings and how progression to full enteral feeding should be implemented. Nursing staff, who carry the main responsibility for initiating and maintaining nutritional support in the PICU were, therefore, empowered to start enteral feeding, via either route, without having to wait for dietetic input. These feeding algorithms facilitated effective time use in the PICU. The impact the audit has had since 1994 on decreasing the time taken to initiate nutritional support, has given the nutritional team confidence that initiation of feeding within 3 hours of admission may be a feasible and achievable goal.

5.3 THE IMPACT ON THE ROUTE OF FEEDING

The route (NG, NJ or PN) of nutritional support remains a topic of great debate for health professionals working in the intensive care units. Consensus however exists that the adequate delivery of nutritional support should be the main goal in feeding the CIC and should not be hampered by the feeding route.

Over the past 15 years there has been a progressive move away from providing nutritional support via the parenteral to the enteral route (NG and NJ). Although Briassoulis et al has shown that the majority of CIC tolerate gastric feeding; the problem in the paediatric critical care setting remains on how to evaluate the tolerance of gastric feeds [23]. The most common method currently in use is measuring and inspecting gastric residual volume [67].

The NG feeding algorithms that were introduced following the baseline audit, therefore, judged tolerance according to four hourly gastric aspirates: if the volume of the aspirate is larger than the four hourly input and mostly undigested, judged by the enteral feeding formula being uncurdled and not stained by gastric juices, then the patient was perceived to have poor gastric emptying. This is however not based on any clinical evidence specific to paediatrics and is open to subjective interpretation. In fact, no information exists on gastric emptying in CIC and only limited information is available on the monitoring of tolerance of gastric feeding in critically ill adults. Soulsby et al has recently published data on the gastric emptying pattern in critically ill adults, highlighting the difficulties in using this as a parameter for assessing gastric feed tolerance[68]. McClave et al supports this concept, explaining that intolerance was difficult to define and that none of the parameters they evaluated (radiography, physical examination, and gastric aspirate volume) emerged as an absolute gold standard [69]. However, in spite of all the shortcomings of gastric residual volume, it remains the most uncomplicated and non-invasive method to assess enteral feed tolerance [70]. Paediatrics has subsequently adopted this practice, knowing that it does not have a firm clinical evidence base, but realising that there is currently no alternative for the monitoring of gastric feed tolerance.

Tolerance is based on the volume of gastric aspirates. In the literature, a broad range of volumes are used to withhold enteral feeding in the adult patient ranging from 50 to 600 ml over 24 hours. Only a few adult studies have provided scientific evidence for the choice of the appropriate level of gastric residual volume that should raise concern about impaired gastric emptying. Mentec et al used a low cut-off of 150 ml or more at two consecutive aspirations and high cut-off of 500 ml at a single aspiration for discontinuation of feeding delivery[67]. Fearful management of enteral nutrition, based on avoidance of high gastric aspirate volumes, might expose intensive care unit patients to unnecessary starvation [67]. McClave et al has confirmed that this is already taking place in many adult intensive care units, with inappropriate cessation of enteral feeding due to lack of data on gastric aspirates. In 45% of patients in this trial, feed was discontinued due to a high gastric residual volume, defined as a residual feeding volume of more than 200ml [69] . This has lead to the introduction of postpyloric feeding (NJ) in many adult and PICU.

The audit cycle on the PICU has revealed several of the problems associated with the route of feeding. The baseline audit in 1994-1995 indicated that 80% of the all patient were fed gastrically, 1% via a NJ tube and the rest parenterally. The NG feeding algorithms that were introduced after the first audit improved total delivery of energy as the 1997-1998 audit confirmed. There was however a dramatic shift in the route of feeding, with an increased number of patients receiving PN (19%). It can be hypothesised that the suggested regime of monitoring NG tolerance according to a four hourly gastric residual volume, lead to an increased number of patients being diagnosed with perceived gastroparesis, which resulted in more PN being ordered for patients. It is also possible that the baseline audit raised the profile of nutritional support on the unit since patients that were intolerant of gastric feeding were previously kept nil by mouth (NBM) for a longer period of time, prior to starting PN. This notion might have been changed by the audit process [70].

If gastroparesis is present, small bowel motility has been shown to be preserved [70]. Small bowel feeding (NJ) is therefore a useful alternative, if gastric feeding fails. The NJ route has been shown to be a safe and well-tolerated method of feeding both in the paediatric and adult critically ill patient with perceived gastroparesis and at an increased risk of aspiration [45, 46].

This paved the way for the development of a blind NJ placement technique and subsequent feeding algorithms, which were not dependant on gastric aspirates (Appendix A). These feeding algorithms were based on the same age categories as the

NG algorithms, providing information on how to initiate NJ feeding, to increase the feeding rate, suitable feeds and the monitoring of tolerance. All the patients in this study received a post-pyloric tube, placed at the bedside, facilitated by pH testing and auscultation. No gut motility agents (i.e. erythromycin), as suggested by many authors were used during the placement [71]. The position of the feeding tube was tested with a blue-dye method, which is a one-off dose of 0.1 ml of blue dye in 20 ml of sterile water, previously validated in the unit [50]. Contrary to the notoriety of NJ tubes, a blind placement success rate of 96% was maintained and the feeding tubes stayed in situ for an average of 5 days, which correlates with the mean stay on a PICU [33].

In a study by Hildebrand et al, a higher proportion of patients receiving enteral formula post-pylorically achieved their nutritional goals compared to gastrically fed; thereby increasing the quantity of nutrients delivered to the patient during hospitalization [72]. Meeting enteral nutrition goals decreases the prevalence of malnutrition and associated risks in the hospitalized patient. Infants and children are often admitted to the hospital with pre-existing malnutrition and a decreased delivery of nutrients during hospitalization will exacerbate malnutrition. The length of hospitalization can reflect the benefits of adequate nutrient administration and the success of patient care [38]. Hildebrand et al also found, that gastrically fed patients were hospitalized for a longer period of time and reached their nutritional goals later than post-pylorically fed patients [72]. It can be argued, that although there are multiple factors influencing a patients' length of stay in the hospital, post-pyloric feeding may have in part contributed to a decreased length of hospitalization in the patients examined. This decrease in the average length of stay could result in a substantial decrease in hospitalization costs.

The audit in 2001, confirmed that the introduction of the NJ placement protocol together with the feeding algorithms, had led to a significant decrease in CIC fed via the parenteral route (19% of patients received PN according to the 1997-1998 audit, this was reduced to 1 % in 2001, with an increase in NJ feeding of 4% in 1997-1998 to 20% in 2001). The success of the NJ placement protocol raised the profile of post-pyloric feeding, which in turn led to the procedure being integrated into the training of any new staff member. As confidence in the procedure grew, so did the number of placements. Briassoulis et al reported that 86% of patients in their study tolerated NG feeding, in contrast to the 79% according to the 2001 audit [23]. It could be legitimately argued that a proportion of our patients could have been adequately fed via the NG route. The placement of NJ tubes remains a more invasive procedure in comparison with NG tube placement and there are some reports of bowel necrosis in the adult population following NJ feeding [73]. It is however difficult to confirm inappropriate overuse and adverse effects retrospectively. A further audit, focusing only on the route of feeding might be able to confirm weather the NJ route is used appropriately on the unit. The NG route should still be the preferred route of feeding, but if not available or possible, NJ feeding should be favored, instead of PN.

By addressing the route of feeding, it has also enabled the unit to identify other areas of nutrition practices, which could be improved through a well designed nutritional protocol. Based on a study by Jacobs et al, transpyloric feeding during mechanical ventilation and up to time of tracheal extubation was found to be comparable with those that were kept nil-by-mouth for 4 hours pre and post extubation [48] . The effect this practice will have of on the nutrition practices in the unit will be reviewed following the next audit, but one could hypothesise that the introduction of this method will promote better energy delivery during the pre-extubation period.

5.4 THE IMPACT ON ENERGY REQUIREMENTS

Early enteral nutrition, the appropriate feeding route and the related feeding algorithms are ultimately all aimed at improving the delivery of energy to the child in the PICU. The impact the auditing cycle has had on the feed delivery can be seen with an increase in the number of patients achieving both 50% and 70% of the EAR for energy.

Using the EAR for energy to assess adequacy of delivery of energy has its limitations: it is the nominal mean of the population and it has not been developed for the sick child, but rather the healthy population. It was however the only way the researchers could objectively assess energy delivered. The verdict is still pending on actual energy requirements in the critically ill child. Most literature however has found that current predictive equations are not reliable in the prediction of energy requirements in the CIC [55, 75]. The choice of any of the predictive formulae as well as the addition of stress factors would introduce bias, especially in the light of having two dietitians appointed in the unit during the auditing period from 1994 to 2001. The EAR for energy made it possible for data to be compared and to judge the adequacy of energy delivery, without being limited by an inaccurate weight.

Currently, indirect calorimetry has been suggested as the most accurate method of establishing energy requirements for CIC. However even this technique is controversial due to two reasons: the methods of conducted studies have been poorly

Standardized [75] and available data indicate clinically significant day-to-day variation in energy expenditure measurements. The latter implies that it would be theoretically necessary to repeat measurements on a daily basis, which is simply not possible for many of the intensive care units due to the technical and time constraints [56]. The technical constraints include:

- Poor accuracy in patients with an inspired F_{IO2} >60% and an air leak around the endotracheal tube of more than 10% [4]
- Enteral and parenteral feeding should be discontinued at least 4 hours before the testing to assure a post absorptive state
- Any routine nursing care should be completed 1 hour prior to the energy measurement
- The patient should be tested in a thermoneutral environment [76]

Only under the above conditions will a steady state be achieved [77]. For the purpose of these audits, it is clear that it would not have been feasible to use indirect calorimetry as the gold standard for energy delivery on a day-to-day basis.

Data for patient receiving more than 50% and 70% of EAR for energy during each audit was analysed and then compared with each other, to assess the impact of the auditing process. The reasoning behind using these two cut-offs were partly based on a study by Briassoulis et al, which reports energy expenditure to be closer to the BMR (see section 2.4) [4]. Therefore the observers used 70% of the EAR as cut off value, representing the BMR. The 50% of EAR cut-off value was chosen, to enable comparison with similar studies. A study performed in the Children's Hospital in Illinois, St.Francis, used the Recommended Dietary Allowance (RDA) for comparison of energy delivery. In this study 52% of the subjects received 50% or more of the

RDA on day three [25]. Our data from 2001 shows similar results to this study, with 58% of patients receiving more than 50% of the EAR by day three.

The introduction of all feeding algorithms, NG, NJ and NJ placement procedure has facilitated the improved delivery of energy. However, in spite of a well designed auditing process, feeding protocols and motivated staff, the reality remains that only 58% of CIC reached more than 50% of the EAR and 35% more than 70% of the EAR. If the literature is correct in comparing energy requirements to the BMR during the acute phase, then only 35% received full nutritional support in our unit by day three. Several studies exist investigating the factors that impede adequate delivery of nutritional support. These factors include stopping enteral feeding due to a gastric residual volume exceeding an arbitrary selected volume[78], diarrhoea, procedures (endoscopy, bronchoscopy, magnetic resonance imaging) and tube displacement.[28,76] Reasons for discontinuing enteral tube feeding on the PICU of St.Mary's were only documented in the 2001 audit; therefore data was not used in the data analysis process. Contrary to the above adult data, our PICU did not discontinue enteral feeding for excessive gastric residual volume, but mostly for procedures (surgery, changing from NG to NJ feeding, endotracheal tube change, extubation). The PICU's extubation protocol states a period of NBM 4 hours prior to extubation, the 2001 data however suggested that 53% of our population group were NBM for more than 6 hours prior to extubation. Thus whilst there have been clear improvements in all areas of nutrition in the PICU, there is still potential for further improvement, especially in the units extubation protocol.

This auditing process has been shown to have a positive impact on nutritional practice, but several shortcomings have been identified, which could have influenced the findings.

5.4 SHORTCOMING OF THE AUDITING PROCESS

Nutritional support in the critical care setting remains a dynamic area, awaiting new research to enable improved medical and nutritional care, and the development of specialised feeds.

It can be argued that since 1994, when the audit process was initiated, improved technology (i.e. new feeding tubes, better enteral feeding formulae, better medical care) and nutritional research (tolerance on NJ feeding, safety of early EN) have contributed to the improved nutritional care on the PICU at St Mary's Hospital. It would be virtually impossible to retrospectively ascertain how much of the improvement was due to new technology, the auditing process and the introduced of the clinical guidelines. However, a more uniform audit period (only over 1 year versus 2 years) is likely to provide better information on the impact of audit as it provides more of a snapshot of practice rather than changes in practice over time.

The timing of the audits can also be criticised for affecting audit data. The audits were not repeated exactly on a two year basis and the length of auditing and subsequent numbers of patients included in each audit were different. This can be explained by the change in the units' number of beds (from 4 to 8) and staffing. This will be addressed with future audits, which will be repeated on exactly a two year basis, using 100 patients and over a one year period only.

This audit could be criticised for not allocating some scoring system to the severity of disease. Torres et al, have used the PRISM scoring system during their audit on nutritional support in a PICU, which made it possible to judge what the impact of disease had been on feeding [25]. Although patients had been categorised according to diagnosis, this would have not provide any indication on the severity of disease. At first glance the diagnostic categories seem comparable. During the auditing cycle, a new meningococcal vaccine (A and C) had been introduced. Early post-licensure data indicate that this vaccine has shown significant efficacy in reduction of invasive meningococcal disease in all age groups. The full impact of vaccination will be determined once all age groups are immunised [79]. The PICU at St.Mary's hospital has seen a reduction in patients with severe meningococcal septicaemia, which may have reduced the number of patients included in the 2001 audit with severe sepsis, by implication the number of patients with severe disease, could have been reduced.

CHAPTER 6: CONCLUSION

Recent data published by Hulst et al[80] found that 24 % or all PICU admissions continue to appear malnourished. In the light of this disturbing evidence it seems pertinent to implement new practices (i.e. auditing) that will make an impact on nutritional support in a PICU.

Continuous auditing and the subsequent introduction of clinical guidelines in a PICU improves nutritional support, by reducing the time taken for nutritional support to be commenced, increasing the number of patients fed via the enteral route and improving calorie delivery. Whilst we are still waiting for new research to clarify energy requirements of the CIC, the value of gastric residual volume when monitoring NG feed tolerance and the ideal time for enteral feeding support to commence; the feeding protocols developed at St Mary's PICU have been shown to have a positive impact on the units practice and could be used by other PICU's.

The auditing process has also increased the awareness of a need to change, identified areas in need for change and measured change. A dedicated multidisciplinary team can facilitate the changes suggested by an audit through a process of continuous training in the use of the nutritional protocols, the placement of NJ tubes and the general nutritional practice. St.Mary's PICU continues to strive for clinical excellence with the development of a new NJ feeding and extubation protocol, a renewed effort to reduce the time taken to initiate feeding support to within 3 hours of admission and increasing the number of patients receiving 70% of the EAR for energy by day 3. The impact beneficial or adverse will be shown through the auditing process!

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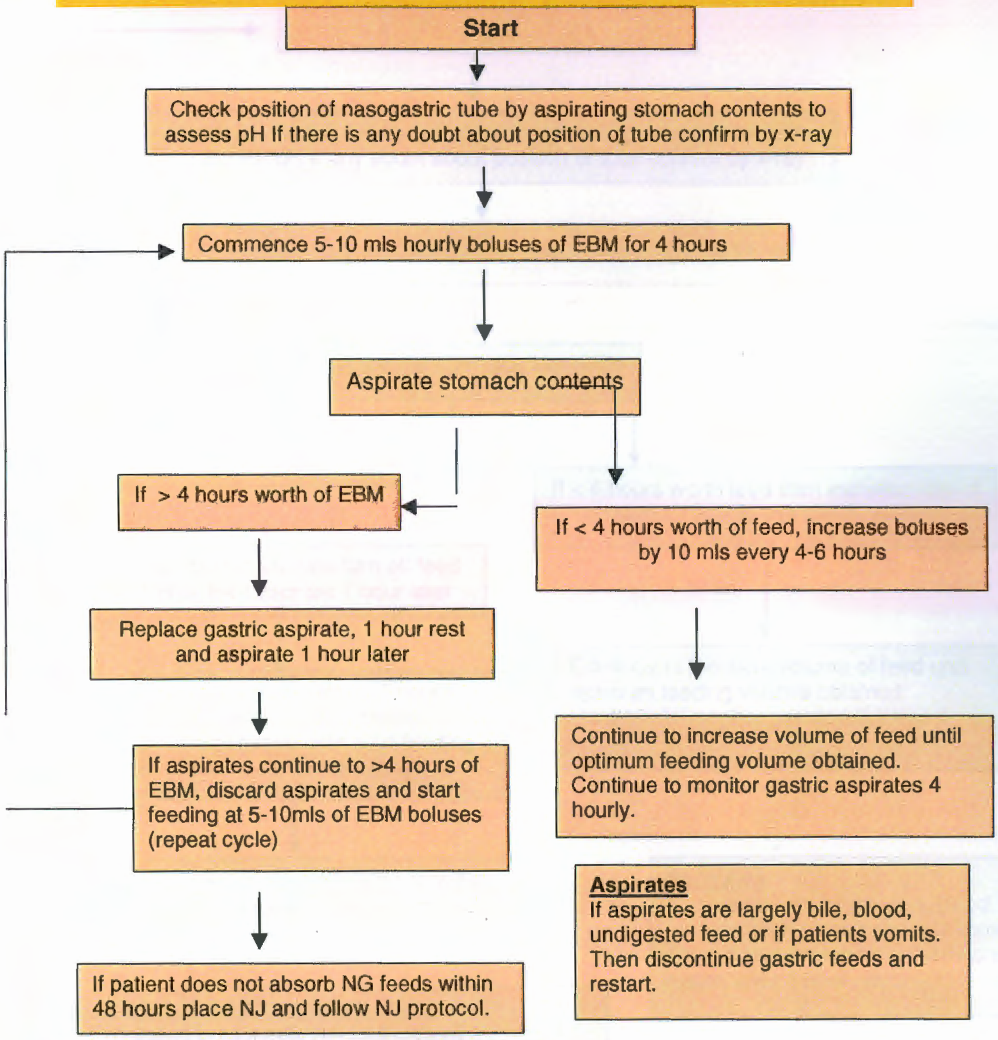
APPENDICES

APPENDIX A

St Mary's NHS
NHS Trust

ENTERAL FEEDING REGIME VIA NASOGASTRIC AND GASTROSTOMY ROUTE FOR INFANTS ON EXPRESSED BREASTMILK (EBM)



Start

Check position of nasogastric tube by aspirating stomach contents to assess pH If there is any doubt about position of tube confirm by x-ray

Commence 5-10 mls hourly boluses of EBM for 4 hours

Aspirate stomach contents

If > 4 hours worth of EBM

Replace gastric aspirate, 1 hour rest and aspirate 1 hour later

If aspirates continue to >4 hours of EBM, discard aspirates and start feeding at 5-10mls of EBM boluses (repeat cycle)

If patient does not absorb NG feeds within 48 hours place NJ and follow NJ protocol.

If < 4 hours worth of feed, increase boluses by 10 mls every 4-6 hours

Continue to increase volume of feed until optimum feeding volume obtained. Continue to monitor gastric aspirates 4 hourly.

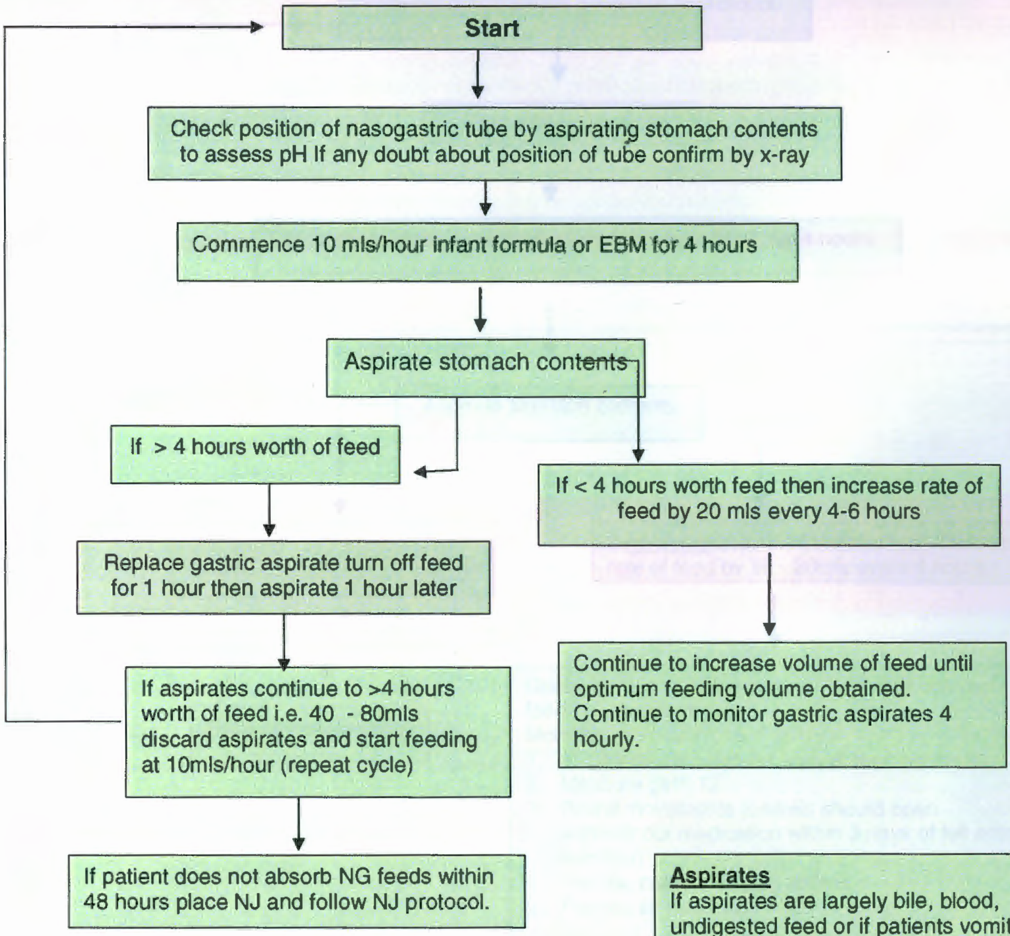
Aspirates
If aspirates are largely bile, blood, undigested feed or if patients vomits. Then discontinue gastric feeds and restart.

Guidelines for the use of EBM

- Motivate Mum to express at the same frequency as previous breastfeeding
- Label the EBM clearly with: name of patient, date and volume
- Check EBM prior to usage with another staff member
- Breast milk lasts 4 hours out of fridge, 24 hours in fridge and 3 months in freezer
- If breast milk fortifier is used, ensure that fortifier is added just before providing feed **or**
- Sachet of fortifier can be added to 50ml fresh/chilled EBM and stored for 4 hours only

St Mary's NHS
NHS Trust

ENTERAL FEEDING REGIME VIA NASOGASTRIC AND GASTROSTOMY ROUTE (0-12 MONTHS <10KG)



Start

Check position of nasogastric tube by aspirating stomach contents to assess pH If any doubt about position of tube confirm by x-ray

Commence 10 mls/hour infant formula or EBM for 4 hours

Aspirate stomach contents

If > 4 hours worth of feed

Replace gastric aspirate turn off feed for 1 hour then aspirate 1 hour later

If aspirates continue to >4 hours worth of feed i.e. 40 - 80mls discard aspirates and start feeding at 10mls/hour (repeat cycle)

If patient does not absorb NG feeds within 48 hours place NJ and follow NJ protocol.

If < 4 hours worth feed then increase rate of feed by 20 mls every 4-6 hours

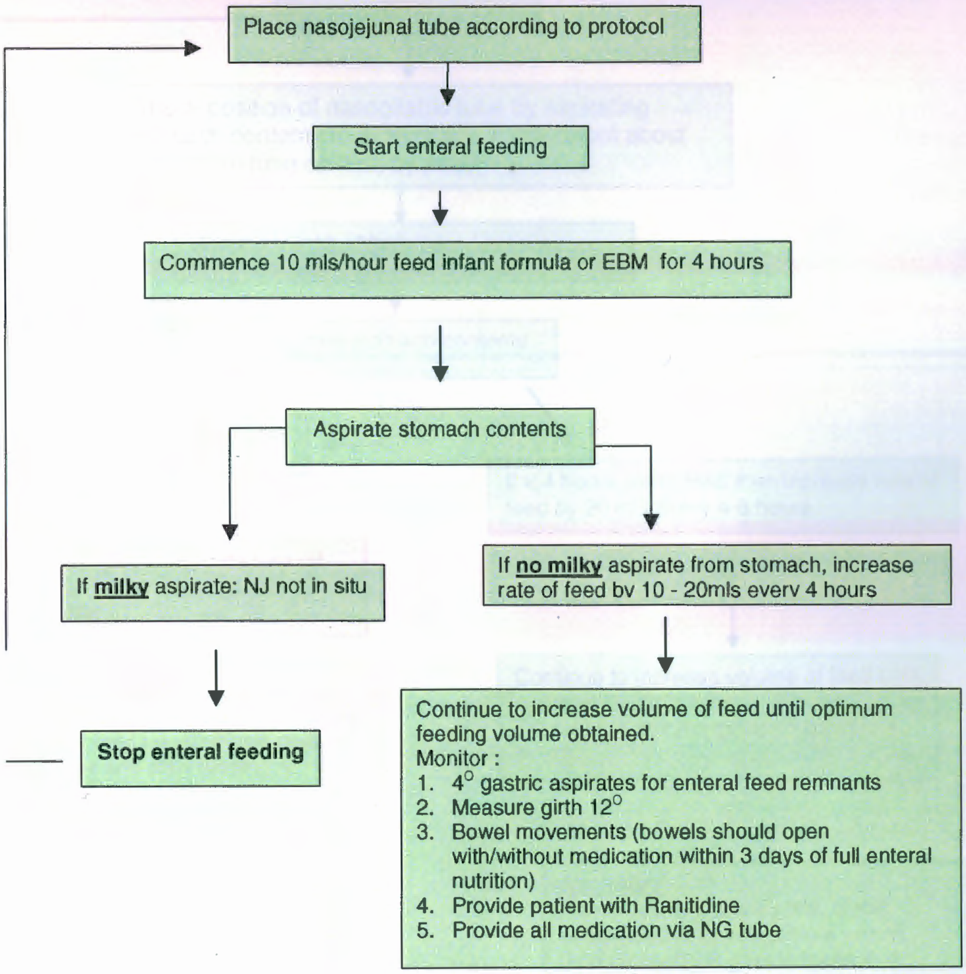
Continue to increase volume of feed until optimum feeding volume obtained. Continue to monitor gastric aspirates 4 hourly.

Aspirates
If aspirates are largely bile, blood, undigested feed or if patients vomits. Then discontinue gastric feeds and restart after 1 hour rest.

Suitable feeds 0-12 months or <10kg
- Expressed breast milk (+/- fortification)
- Standard infant formula
- Preterm infant formula (Nutriprem 2)
- Infatrini (high calorie feed)
- Pregestimil (diarrhoea and milk intolerance)
- Neocate (intractable malabsorption, allergy)
- Soya infant formula

St Mary's NHS
NHS Trust

ENTERAL FEEDING REGIME VIA NASOJEJUNAL AND GASTROJEJUNAL ROUTE (0-12MONTHS <10KG)



Place nasojejunal tube according to protocol

Start enteral feeding

Commence 10 mls/hour feed infant formula or EBM for 4 hours

Aspirate stomach contents

If **milky** aspirate: NJ not in situ

Stop enteral feeding

If **no milky** aspirate from stomach, increase rate of feed bv 10 - 20mls everv 4 hours

Continue to increase volume of feed until optimum feeding volume obtained.
Monitor :
1. 4° gastric aspirates for enteral feed remnants
2. Measure girth 12°
3. Bowel movements (bowels should open with/without medication within 3 days of full enteral nutrition)
4. Provide patient with Ranitidine
5. Provide all medication via NG tube

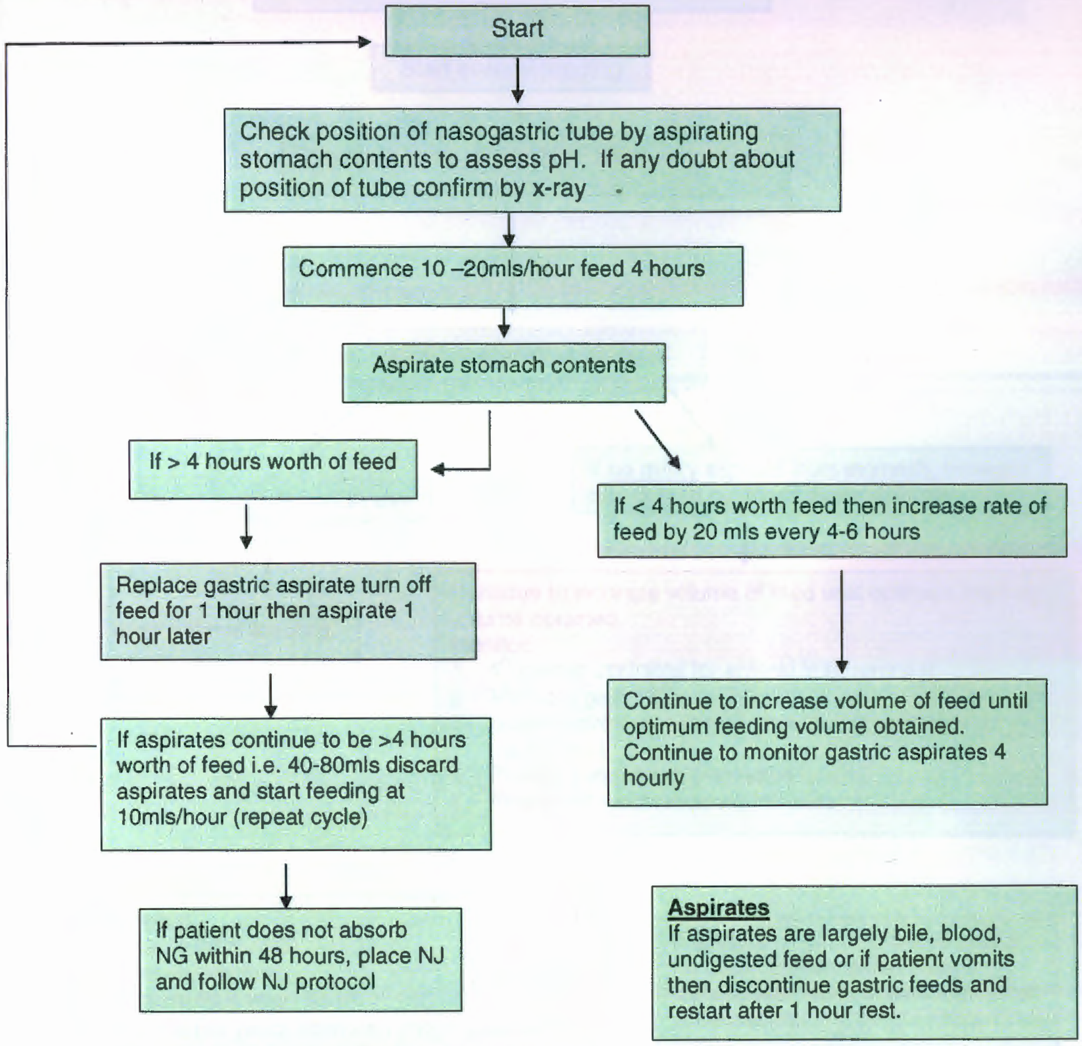
Suitable feeds for 0-12 months (<10kg)

- Expressed breast milk (+/- fortification)
- Standard infant formula
- Preterm infant formula (Nutripren 2)
- Infatrini (high calorie feed)
- Pregestimil (diarrhoea and milk intolerance)
- Neocate (intractable malabsorption, allergy)
- Soya infant formula

If abdominal girth increases discuss with medical staff regarding continuation of feeds.

St Mary's NHS
NHS Trust

ENTERAL FEEDING REGIMEN VIA NASOGASTRIC AND GASTROSTOMY ROUTE (1-6 YEARS 10-20KG)



Start

Check position of nasogastric tube by aspirating stomach contents to assess pH. If any doubt about position of tube confirm by x-ray

Commence 10 –20mls/hour feed 4 hours

Aspirate stomach contents

If > 4 hours worth of feed

Replace gastric aspirate turn off feed for 1 hour then aspirate 1 hour later

If aspirates continue to be >4 hours worth of feed i.e. 40-80mls discard aspirates and start feeding at 10mls/hour (repeat cycle)

If patient does not absorb NG within 48 hours, place NJ and follow NJ protocol

If < 4 hours worth feed then increase rate of feed by 20 mls every 4-6 hours

Continue to increase volume of feed until optimum feeding volume obtained. Continue to monitor gastric aspirates 4 hourly

Aspirates
If aspirates are largely bile, blood, undigested feed or if patient vomits then discontinue gastric feeds and restart after 1 hour rest.

Suitable feeds:

- Paediasure (standard)
- Paediasure with fibre
- Paediasure Plus (high Kcal)
- Pregestimil (<2 years diarrhoea milk intolerance)
- MCT Peptide 2+ (>2 years diarrhoea and milk intolerance)
- Elemental 028 (intractable malabsorption)

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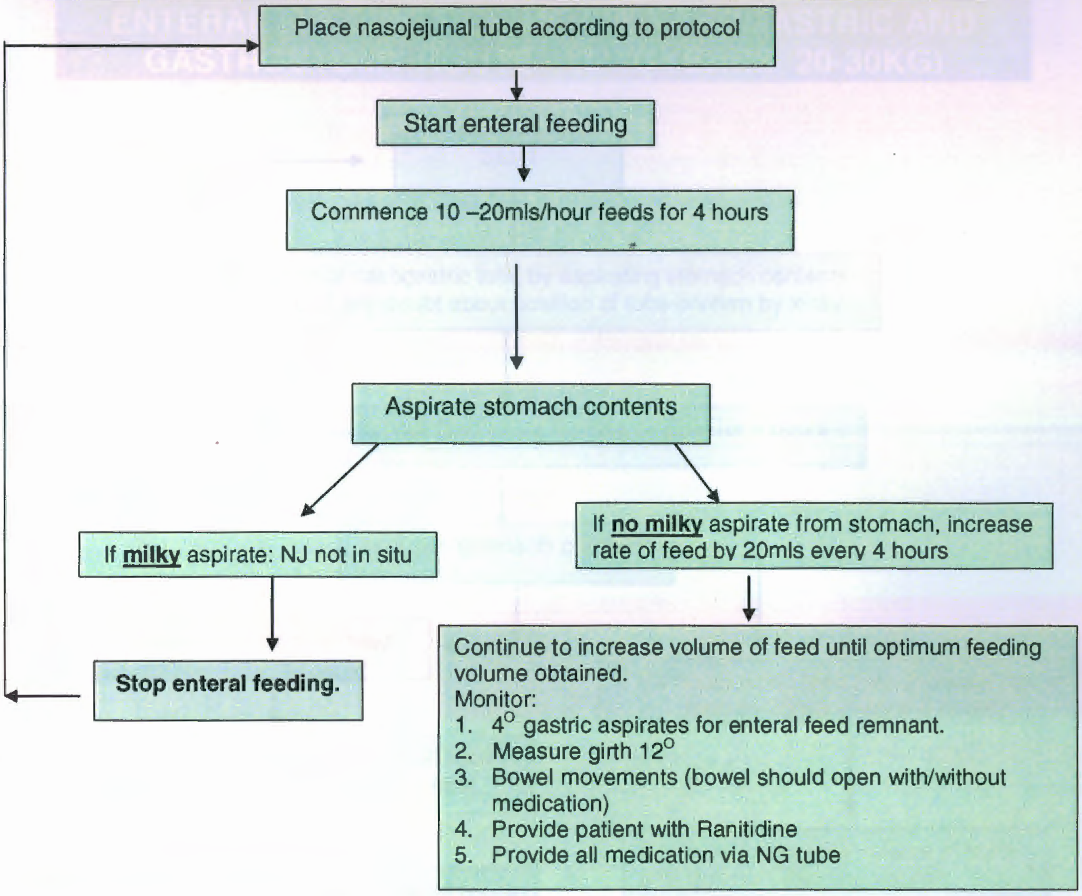
ENTERAL FEEDING REGIMEN VIA NASOJEJUNAL AND GASTROJEJUNAL ROUTE (1-6 YEARS 10-20KG)



Place nasojejunal tube according to protocol

Start enteral feeding

Commence 10 –20mls/hour feeds for 4 hours

Aspirate stomach contents

If **milky** aspirate: NJ not in situ

Stop enteral feeding.

If **no milky** aspirate from stomach, increase rate of feed by 20mls every 4 hours

Continue to increase volume of feed until optimum feeding volume obtained.
Monitor:

1. 4^{O} gastric aspirates for enteral feed remnant.
2. Measure girth 12^{O}
3. Bowel movements (bowel should open with/without medication)
4. Provide patient with Ranitidine
5. Provide all medication via NG tube

Suitable feeds :

- Paediasure (standard)
- Paediasure with fibre
- Paediasure Plus (high Kcal)
- Pregestimil (<2 years diarrhoea milk intolerance)
- MCT Peptide 2+ (>2 years diarrhoea and milk intolerance)
- Elemental 028 (intractable malabsorption)

If abdominal girth increases and/or no bowel motion within 3 days discuss with medical staff regarding continuation.

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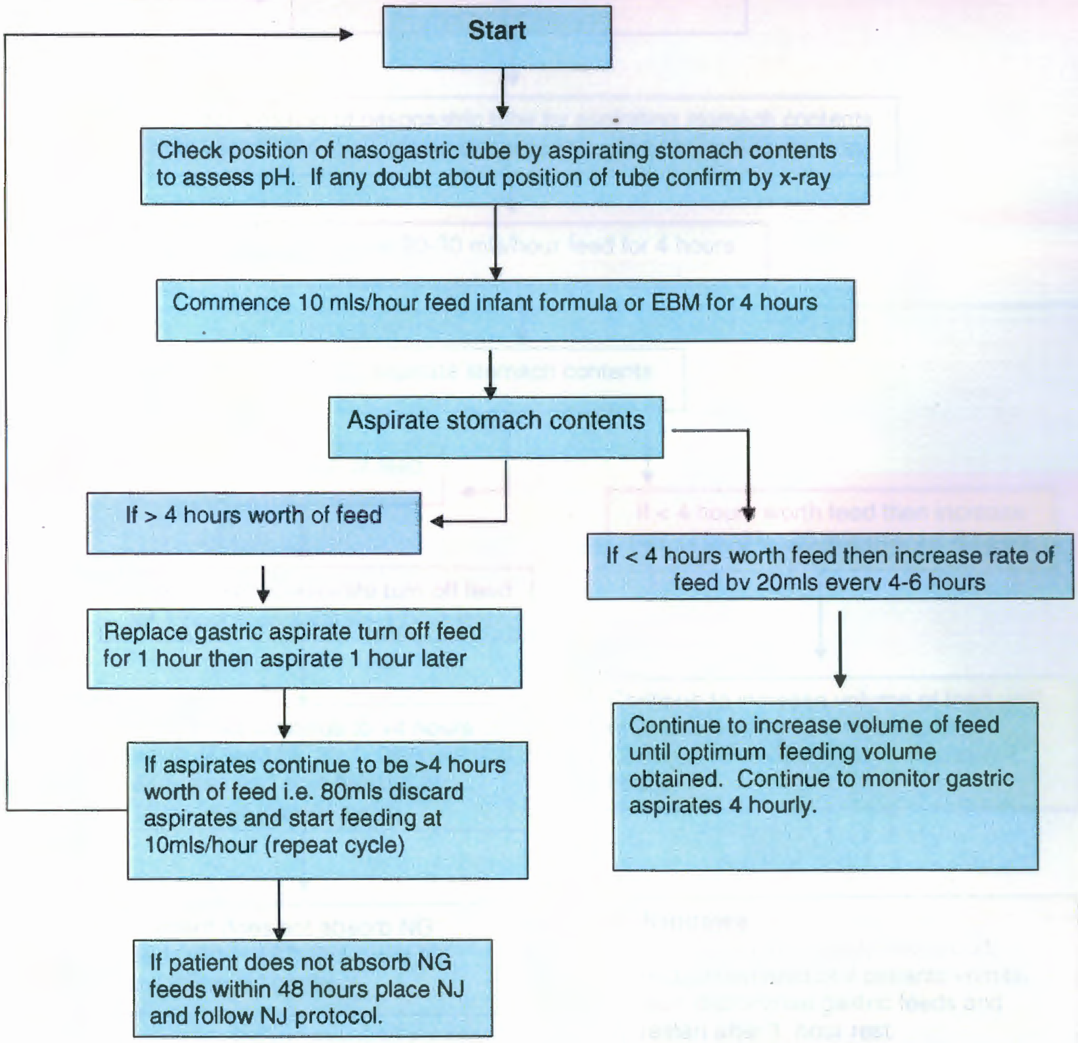
ENTERAL FEEDING REGIME VIA NASOGASTRIC AND GASTROSTOMY ROUTE (6-10 YEARS 20-30KG)



Start

Check position of nasogastric tube by aspirating stomach contents to assess pH. If any doubt about position of tube confirm by x-ray

Commence 10 mls/hour feed infant formula or EBM for 4 hours

Aspirate stomach contents

If > 4 hours worth of feed

Replace gastric aspirate turn off feed for 1 hour then aspirate 1 hour later

If aspirates continue to be >4 hours worth of feed i.e. 80mls discard aspirates and start feeding at 10mls/hour (repeat cycle)

If patient does not absorb NG feeds within 48 hours place NJ and follow NJ protocol.

If < 4 hours worth feed then increase rate of feed by 20mls every 4-6 hours

Continue to increase volume of feed until optimum feeding volume obtained. Continue to monitor gastric aspirates 4 hourly.

Suitable feeds for 6-10 years (20 –30kg)

- Paediasure (standard)
- Paediasure with fibre
- Paediasure Plus (high Kcal)
- Osmolite
- Jevity (added fibre)
- Elemental 028
- Peptisorb (semi-elemental)

Aspirates
If aspirates are largely bile, blood, undigested feed or if patients vomits. Then discontinue gastric feeds and restart after 1 hour rest.

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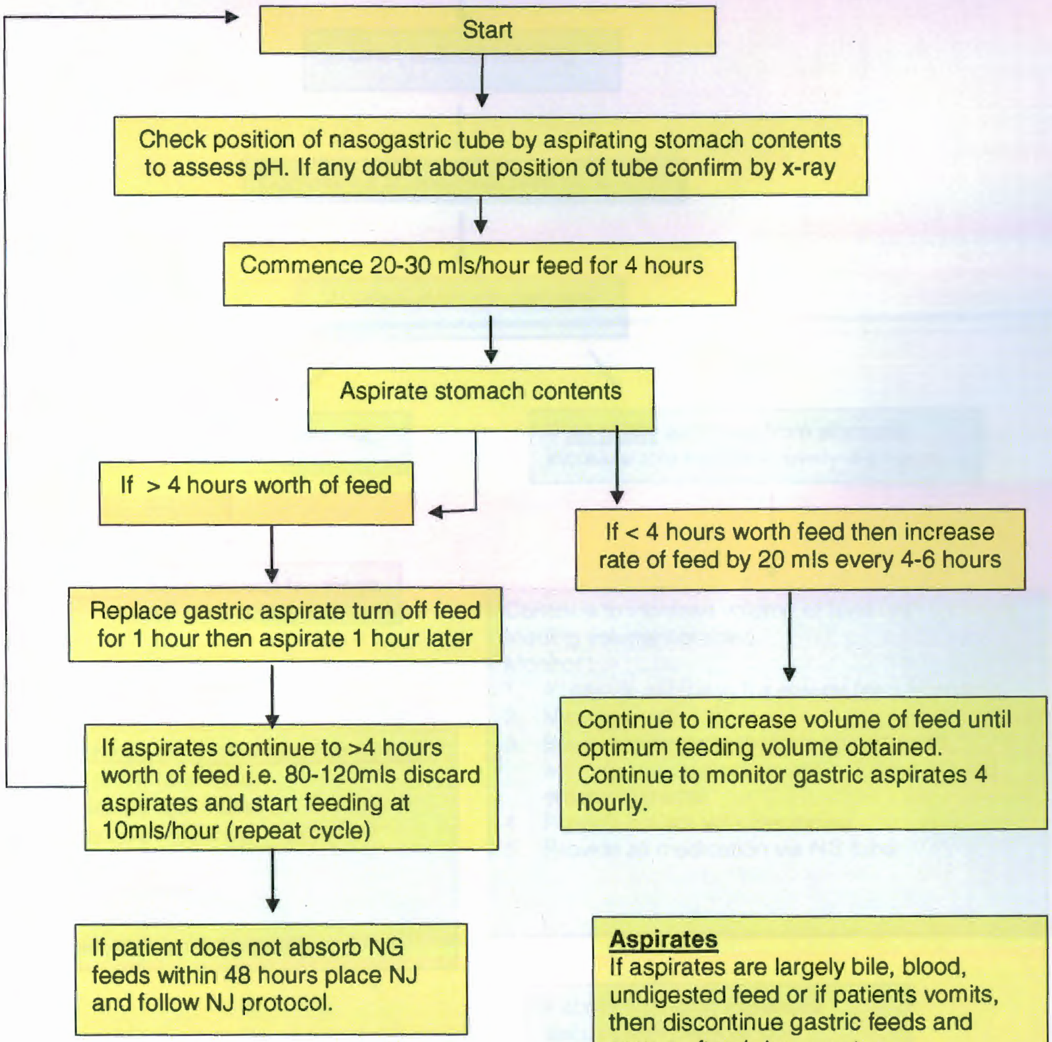
ENTERAL FEEDING REGIME VIA NASOGASTRIC AND GASTROSTOMY ROUTE (>10 YEARS > 30KG)



Start

Check position of nasogastric tube by aspirating stomach contents to assess pH. If any doubt about position of tube confirm by x-ray

Commence 20-30 mls/hour feed for 4 hours

Aspirate stomach contents

If > 4 hours worth of feed

Replace gastric aspirate turn off feed for 1 hour then aspirate 1 hour later

If aspirates continue to >4 hours worth of feed i.e. 80-120mls discard aspirates and start feeding at 10mls/hour (repeat cycle)

If patient does not absorb NG feeds within 48 hours place NJ and follow NJ protocol.

If < 4 hours worth feed then increase rate of feed by 20 mls every 4-6 hours

Continue to increase volume of feed until optimum feeding volume obtained. Continue to monitor gastric aspirates 4 hourly.

Aspirates
If aspirates are largely bile, blood, undigested feed or if patients vomits, then discontinue gastric feeds and restart after 1 hour rest.

Suitable feeds
- Osmolite
- Jevity (added fibre)
- Nutrison Low Sodium (hypernatraemia)
- Nepro (low phosphate, low potassium)
- Elemental 028
- Ensure Plus
- Peptisorb (semi-elemental)

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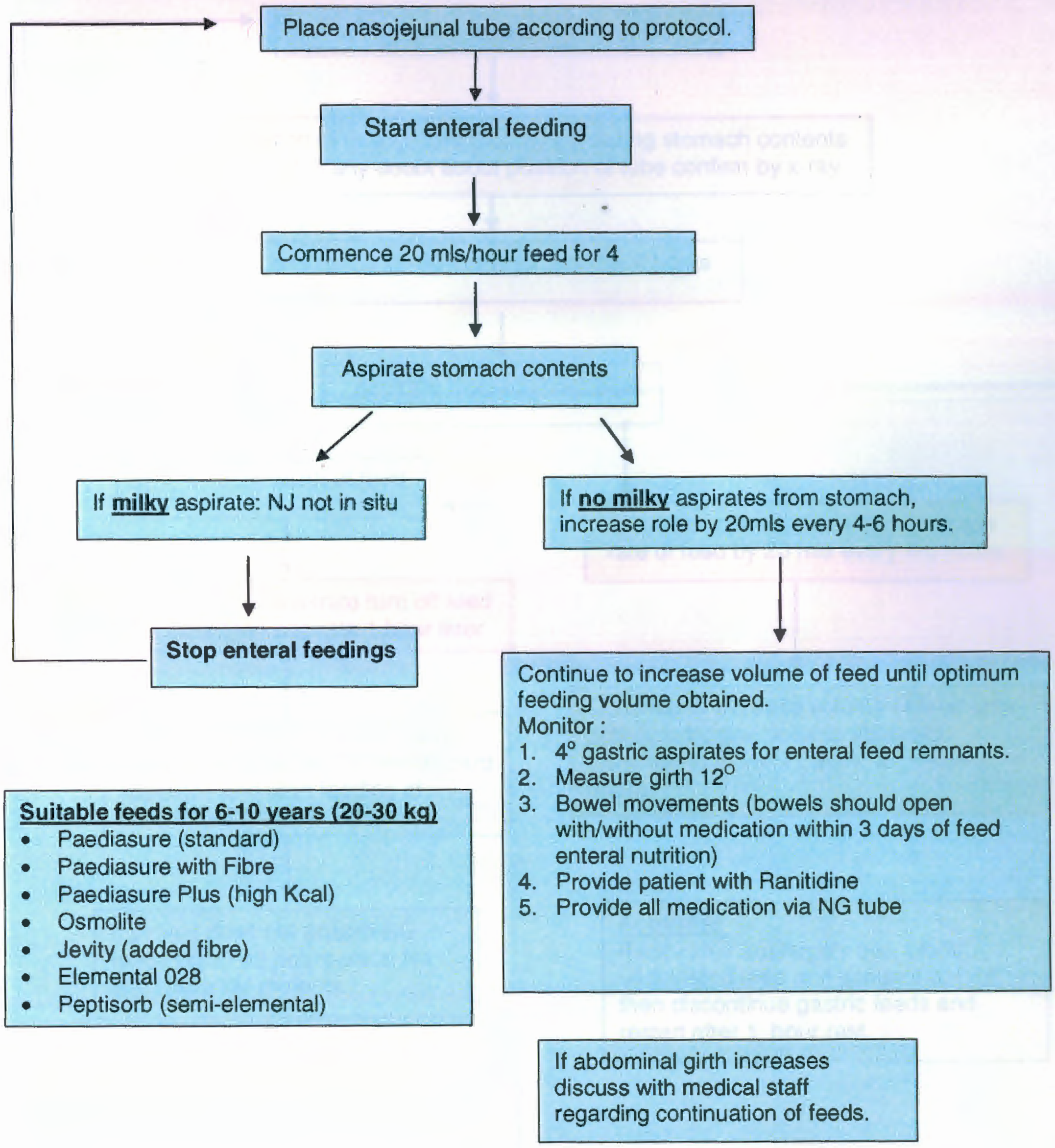
ENTERAL FEEDING REGIME VIA NASOJEJUNAL AND GASTROJEJUNAL ROUTE (>6–10 YEARS 20–30 KG)



Place nasojejunal tube according to protocol.

Start enteral feeding

Commence 20 mls/hour feed for 4

Aspirate stomach contents

If **milky** aspirate: NJ not in situ

Stop enteral feedings

If **no milky** aspirates from stomach, increase role by 20mls every 4-6 hours.

Continue to increase volume of feed until optimum feeding volume obtained.
Monitor :
1. 4° gastric aspirates for enteral feed remnants.
2. Measure girth 12°
3. Bowel movements (bowels should open with/without medication within 3 days of feed enteral nutrition)
4. Provide patient with Ranitidine
5. Provide all medication via NG tube

Suitable feeds for 6-10 years (20-30 kg)
- Paediasure (standard)
- Paediasure with Fibre
- Paediasure Plus (high Kcal)
- Osmolite
- Jevity (added fibre)
- Elemental 028
- Peptisorb (semi-elemental)

If abdominal girth increases discuss with medical staff regarding continuation of feeds.

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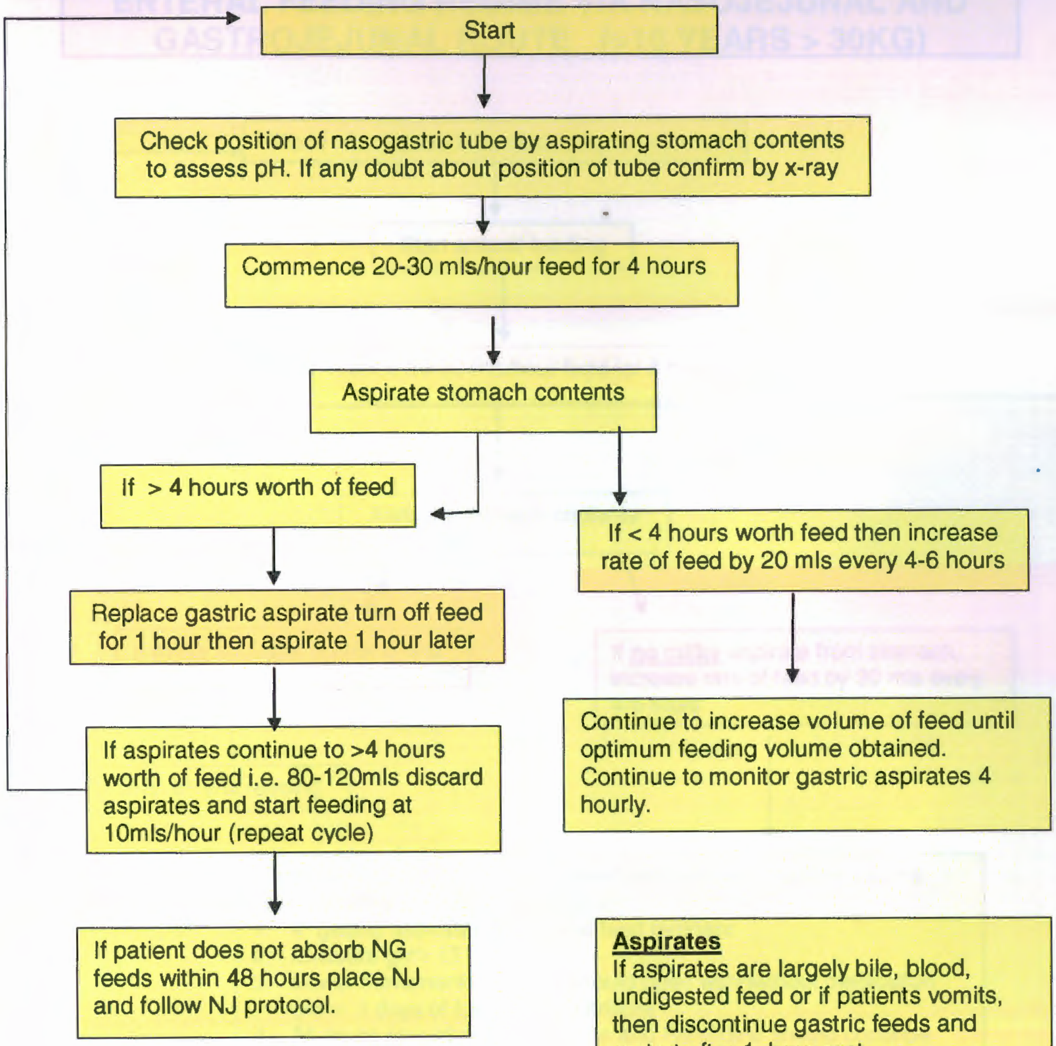
ENTERAL FEEDING REGIME VIA NASOGASTRIC AND GASTROSTOMY ROUTE (>10 YEARS > 30KG)



Start

Check position of nasogastric tube by aspirating stomach contents to assess pH. If any doubt about position of tube confirm by x-ray

Commence 20-30 mls/hour feed for 4 hours

Aspirate stomach contents

If > 4 hours worth of feed

Replace gastric aspirate turn off feed for 1 hour then aspirate 1 hour later

If aspirates continue to >4 hours worth of feed i.e. 80-120mls discard aspirates and start feeding at 10mls/hour (repeat cycle)

If patient does not absorb NG feeds within 48 hours place NJ and follow NJ protocol.

If < 4 hours worth feed then increase rate of feed by 20 mls every 4-6 hours

Continue to increase volume of feed until optimum feeding volume obtained. Continue to monitor gastric aspirates 4 hourly.

Aspirates
If aspirates are largely bile, blood, undigested feed or if patients vomits, then discontinue gastric feeds and restart after 1 hour rest.

Suitable feeds

- Osmolite
- Jevity (added fibre)
- Nutrison Low Sodium (hypernatraemia)
- Nepro (low phosphate, low potassium)
- Elemental 028
- Ensure Plus
- Peptisorb (semi-elemental)

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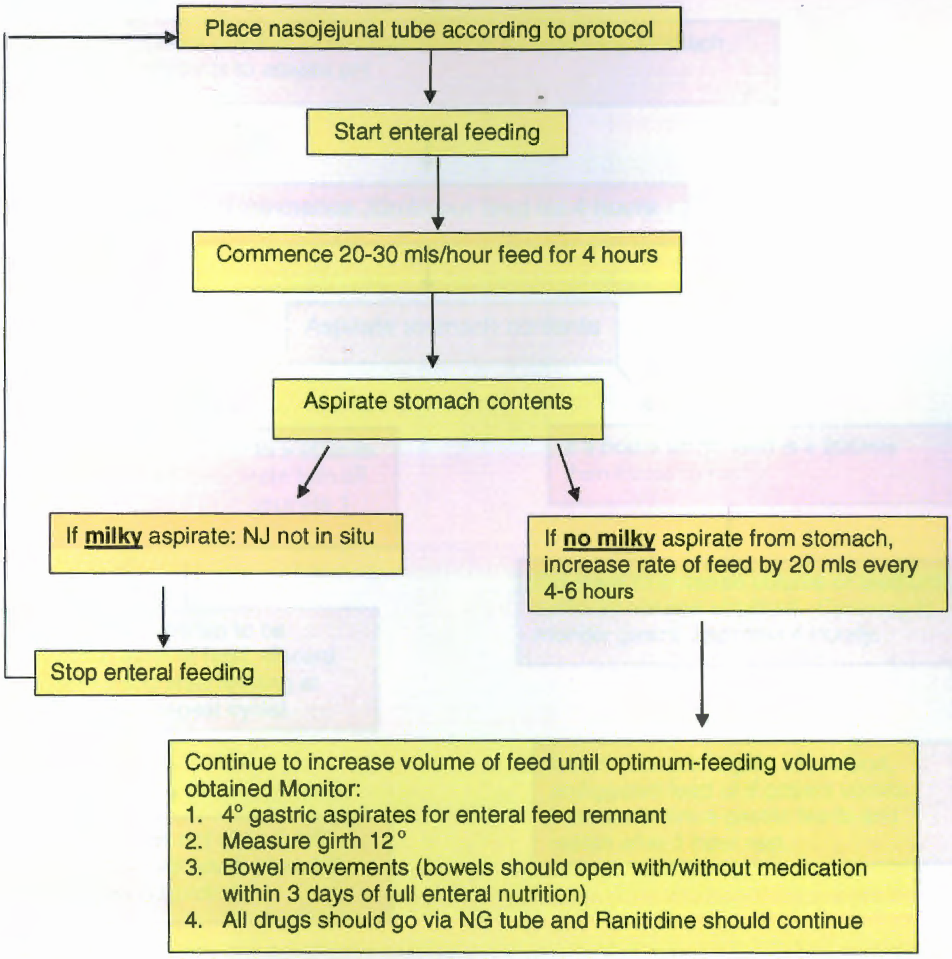
ENTERAL FEEDING REGIME VIA NASOJEJUNAL AND GASTROJEJUNAL ROUTE (>10 YEARS > 30KG)



Place nasojejunal tube according to protocol

Start enteral feeding

Commence 20-30 mls/hour feed for 4 hours

Aspirate stomach contents

If **milky** aspirate: NJ not in situ

Stop enteral feeding

If **no milky** aspirate from stomach, increase rate of feed by 20 mls every 4-6 hours

Continue to increase volume of feed until optimum-feeding volume obtained Monitor:

1. 4° gastric aspirates for enteral feed remnant
2. Measure girth 12°
3. Bowel movements (bowels should open with/without medication within 3 days of full enteral nutrition)
4. All drugs should go via NG tube and Ranitidine should continue

Suitable feeds for >10 years (>30 kg)

- Osmolite
- Jevity (added fibre)
- Nutrison Low Sodium (hypernatraemia)
- Nepro (low phosphate, low potassium)
- Elemental 028
- Ensure Plus
- Peptisorb (semi-elemental)

If abdominal girth increases discuss with medical staff regarding feed continuation.

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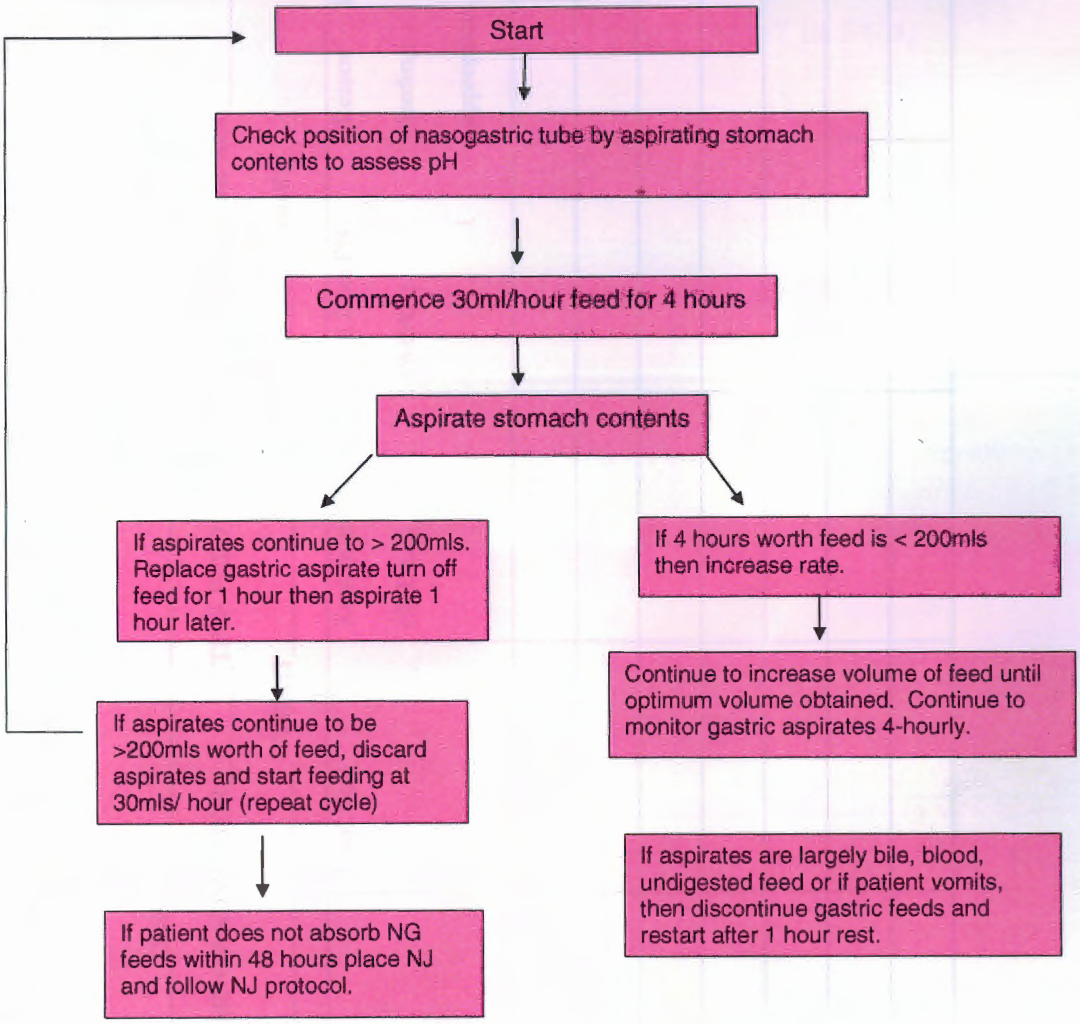
ENTERAL FEEDING REGIME VIA NASOGASTRIC AND GASTROSTOMY ROUTE (>50KG)



Start

Check position of nasogastric tube by aspirating stomach contents to assess pH

Commence 30ml/hour feed for 4 hours

Aspirate stomach contents

If aspirates continue to > 200mls. Replace gastric aspirate turn off feed for 1 hour then aspirate 1 hour later.

If aspirates continue to be >200mls worth of feed, discard aspirates and start feeding at 30mls/ hour (repeat cycle)

If patient does not absorb NG feeds within 48 hours place NJ and follow NJ protocol.

If 4 hours worth feed is < 200mls then increase rate.

Continue to increase volume of feed until optimum volume obtained. Continue to monitor gastric aspirates 4-hourly.

If aspirates are largely bile, blood, undigested feed or if patient vomits, then discontinue gastric feeds and restart after 1 hour rest.

Suitable feeds for >10 years (>50 kg)

- Osmolite (standard)
- Jevity (added fibre)
- Ensure Plus (high Kcal)
- Nutrison Low Sodium (hypernatraemia)
- Nepro (low phosphate, low potassium)
- Elemental 028
- Peptisorb (semi-elemental)

APPENDIX B

PICU AUDIT FORM

HOSPITAL NUMBER__________________________DOB______________________________________

DATE OF ADMISSION____________________ TIME OF ADMISSION________TIME FEED STARTED________EAR FOR AGE_____________

NG/NJ/PN ? DIAGNOSIS____________________________________ WEIGHT__________________(accurate/estimated)

Day	Vol EN	Vol PN	Total Kcal	Kcal from EN (% EAR)	Kcal from PN (%EAR)	Reason for not feeding (use appropriate code)
Day 1						
Day 2						
Day 3						
Day 4						
Day 5						
Day 6						
Day 7						

APPENDIX C

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ST MARY'S HOSPITAL

BEDSIDE NASOJEJUNAL TUBE PLACEMENT IN PICU

1) Equipment and Initial Procedure

Choose the appropriate NJ tube, Gloves, Apron, Aquagel, pH paper, two (20ml) syringes, sterile water, gauze, tape measure, tegaderm and stethoscope.

Explain procedure to parents and child if appropriate. Check child is adequately sedated.

Using a clean technique, take tube out of packaging and remove the guidewire. Lubricate the guidewire with Aquagel by wiping the gauze over the wire. Replace guide wire in tube.

Using a tape measure, measure an approximate length for both gastric and jejunal position and document - ear – nose –gastrum – right lower abdomen.

Elevate bed slightly to 15-30° and turn the patient (if the clinical condition allows), in a right lateral oblique position (left side up).[1,2]

2) Procedure – Gastric Placement

Empty and decompress stomach with nasogastric tube already in situ.

a) Insert NJ through either nostril, aiming the tip parallel to the palate and nasal septum until tube is in stomach.

b) Confirm gastric placement by aspirating gastric fluid and testing with litmus or pH paper (pH 4 to 5)[1]. *Please note that Aquagel is slightly acidic and might affect the accuracy of pH paper.*

d) If patient starts to cough repeatedly, the saturation monitor shows a decrease, there is an indication of cyanosis or you feel resistance during tube placement remove the tube and go back to a). If no problems encountered go to 3).

And/or: c) Auscultation of air and withdrawal of air by a 20ml syringe (listen with stethoscope).[1]

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1) Zaloga G.P. Bedside method for
2) Ugo et al postpyloric placement
3) Bengmarks. Progress in Peri-op

December 1991.

Procedure – Jejunal Placement

a) Continue to advance NJ tube whilst slowly rotating it close to the nostril. Position can be checked by injecting air and listening with stethoscope by a second Nurse/Doctor. A small amount of resistance can be felt as you advance through the Pylorus.

b) Once you have reached your approximate length: i) Attempt aspirating from the tube. ii) Inject air, listening over the lower abdomen, or iii) confirm sonographically if it is difficult to detect injected air. To ensure distal duodenal/proximal jejunal placement, advance an additional 5-10cm.

d) Withdraw tube to stomach and confirm placement with pH paper. Go back to a). If procedure continues to be unsuccessful, go to 4). If no problems are encountered go to 5).

c) If air is not easily injected and resistance is met, it is a indication of nasoenteric tube either being coiled or kinked.

4) Motility Drugs

Administer 0.1mg/kg of metoclopramide IV[3]. If patient is prescribed Erythromycin and has received a dose within 30 minutes prior to NJ placing, then omit the dose of metoclopramide

5) Confirming Transpyloric Placement

Remove guidewire. Mix 0.1ml of methylene blue or blue colourant with 20ml of enteral feed (<5kg = 5ml; 5-15kg = 10mls; >15kg = 20mls) and administer through the nasojejunal tube. Aspirate from nasogastric tube within 10 minutes of administering the dye. Transpyloric placement is confirmed by the absence of blue dye in NG secretions.

⇩

If placement unsuccessful, attempt sonographic method. A new tube needs to be re-inserted for this method.

Ranitidine should be provided to all patients being NJ fed.
All chest x-rays should include the abdomen in patients with NJ Tubes.

NJ tubes: Nutricia, 6, 8, 10 G

Length 90cm and 120 cm

APPENDIX D

Estimated Average Requirements

EAR - MJ/day (kcal/day)

Age	*Males*		*Females*	
	(MJ)	*(kcal)*	*(MJ)*	*(kcal)*
0-3 mo	2.28	(545)	2.16	(515)
4-6 mo	2.89	(690)	2.69	(645)
7-9 mo	3.44	(825)	3.20	(765)
10-12 mo	3.85	(920)	3.61	(865)
1-3 yr	5.15	(1230)	4.86	(1165)
4-6 yr	7.16	(1715)	6.46	(1545)
7-10 yr	8.24	(1970)	7.28	(1740)

EAR - MJ/day (kcal/day)

Age	*Males*		*Females*	
	(MJ)	*(kcal)*	*(MJ)*	*(kcal)*
11-14 yr	9.27	(2220)	7.72	(1845)
15-18 yr	11.51	(2755)	8.83	(2110)
19-50 yr	10.60	(2550)	8.10	(1940)
51-59 yr	10.60	(2550)	8.00	(1900)
60-64 yr	9.93	(2380)	7.99	(1900)
65-74 yr	9.71	(2330)	7.96	(1900)
74+ yr	8.77	(2100)	7.61	(1810)

Source: British National Formulary [83]