



REVIEW

Neonatal parenteral nutrition: Review of the pharmacist role as a prescriber



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Abstract *Introduction:* In the context of the continuous quest to improve the care of the neonates especially the critically ill premature, the extended role of pharmacists in the process of parenteral nutrition order writing and effective participation in decision-making especially in the neonatal population is increasingly important.

This review aims to present results from literature review of available evidence on the pharmacists' role in neonatal parenteral nutrition therapy.

Material and methods: Key medical, clinical, and review databases were searched; relevant articles were retrieved and evaluated.

Results and discussion: A total of 19 papers out of 7127 searched papers met the criteria for inclusion, discussing the review topic.

The main focus of the selected papers was on parenteral nutrition practice as related to the pharmacy practice.

The overall quality of studies was mixed.

Conclusion: Overall, the review presents the up-to-date status of the most recent analysis being undertaken on the topic of pharmacist involvement in the parenteral nutrition order writing practices and more specific in the neonatal population over the period from 1979 to 2013.

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The overall impression is that the practice of pharmacist writing neonatal parenteral nutrition orders already exists, but still limited if compared with the practice pharmacist writing adult parenteral nutrition orders which is much more established in many countries.

There was no single clinical study evaluating this practice, as we were able to retrieve only two surveys, which make it difficult to evaluate the pharmacists' role in this area.

Nevertheless, despite the wide variation in literature types, characteristics and quality, there are consistent patterns across all the reviewed literature that competencies of the pharmacist in this field are well represented, which make it very important to carry out good quality clinical studies in this field.

Finally, we are currently conducting a prospective clinical study to evaluate the impact of clinical pharmacist as a neonatal PN prescriber, this impact will be judged through the study outcomes as reducing the metabolic and electrolytes complications and increasing the mean daily weight gain during PN therapy and reducing the average number of days of PN till enteral feeding is achieved.

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Contents

1. Introduction	430
2. Materials and methods	431
3. Results	431
4. Discussion	431
4.1. Benefits of nutrition support team	431
4.2. Variable levels of pharmacist involvement in PN, other than writing PN orders	431
4.3. Benefits of pharmacist involvement in PN	438
4.4. Pharmacist writing PN orders	438
4.5. Pharmacist writing neonatal PN orders	438
5. Conclusion	438
References	439

1. Introduction

Neonates are the most patients population that benefits from parenteral nutrition therapy, as most of the prematures and very low birth weight infants < 1500 g will need immediate after birth nutrition support therapy through parenteral access due to their inability to tolerate/contraindicated enteral or oral feeding. As such, parenteral nutrition (PN) is an essential component of care for those infants. There is good evidence that some preterm infants may fail to grow adequately (Ehrenkranz et al., 1999; Wood et al., 2003). Poor growth can be associated with poor neurodevelopmental outcomes in extremely preterm infants, with a lower weight at discharge associated with an increased risk of neurodevelopmental impairment (Ehrenkranz et al., 2006). One reason for this poor growth may be that these infants receive inadequate nutrition in the first weeks of life.

Recommendations for the optimal nutrient intake of preterm infants exist (Agostoni et al., 2010), however, there is evidence that these targets are not achieved (Embleton et al., 2001; Grover et al., 2008; Martin et al., 2009). Achieving recommended nutrient intakes in these infants is a major challenge, and feeding practices can be variable. This was demonstrated by Cooke et al. (2004) who showed that units offering the same level of care had significant variations in postnatal growth. Another unique problem, frequently encountered with the neonatal parenteral nutrition ordering practice is the provision of low calories and failure to reach the minimum required calories needed for proper weight gain, and this problem is of great

significance as the single most important goal for neonatal parenteral nutrition is to maximize weight gain and provide enough calories and protein to build new tissues. And to ensure the provision of the required calories and protein for those infants; the pharmacist input is of great significance as to calculate the daily provided calories and protein – from parenteral and enteral nutrition – for the infants and to modify the parenteral nutrition orders accordingly until reaching the goals.

Understanding the barriers to implementing a change in practice is key to the development of a successful intervention (Grol, 1997; Grol and Grimshaw, 2003), and there is evidence that guidelines alone are often not enough to bring about or maintain a change in practice, and that more multifaceted implementation strategies are required (Grimshaw et al., 2004; Grol, 2001; Grol and Grimshaw, 2003; Mettes et al., 2010).

Evidence demonstrates that physicians have minimal training and experience in this area of nutrition support (Gales and Riley, 1994), and consequently this has led to the development of multidisciplinary nutrition support teams in many health care facilities (Naylor et al., 2004). According to a position paper by the European Society of Paediatric Gastroenterology, Hepatology and Nutrition (ESPHGAN) Committee on Nutrition, current education of pediatricians in clinical nutrition is insufficient to ensure appropriate assessment of nutritional risk (Agostoni et al., 2005).

Improvements can be made in the nutrition support process. The nutrition support pharmacist will be a key participant in the maintenance and improvement of the nutrition

care process (Mirtallo, 2007). In a recent article, reviewers proposed a paradigm shift of pharmacy nutrition support to move beyond PN and drug-nutrient interactions and become partners in the interdisciplinary approach to nutrition care plans and offer their assistance with the nutrition care plan's implementation and monitoring of its effectiveness (Mirtallo and Sacks, 2013).

In the context of our continuous quest to improve the level of care to the neonates especially the critically ill prematures, the extended role of pharmacists in the process of parenteral nutrition order writing and effective participation in decision making especially in the neonatal population is increasingly important to better utilizing the pharmacists' vast pharmaceutical, pharmacological and clinical knowledge.

In this review we are mainly concentrating on the current areas of involvement for pharmacist in the neonatal parenteral nutrition practice. Also we aim at determining the impact of the pharmacist involvement in this practice on the patients' clinical outcomes and/or cost optimization of PN therapy. Throughout this review we will investigate if the pharmacist as a prescriber of neonatal PN orders had favorable impact on the patients' clinical status.

2. Materials and methods

An extensive literature review was conducted across various literature databases including, British Medical Journals (BMJ), Cochrane Library Database, EBSCO, Karger Journals, OVID SP, SAGE Journals, Science Direct, Scopus Database, Springer Link, Web Of Knowledge (ISI).

The search was conducted based on a diversity of key words related to the review topic, during the period from 1979 to 2013.

Keywords used for searching in various data sources:

Neonate, Neonatal intensive care unit, premature, preterm, parenteral nutrition, total parenteral nutrition, pharmacy, clinical pharmacist, and pharmacist.

The articles were included in the final review only if they focused on and/or reported the pharmacists' involvement in parenteral nutrition practice other than the compounding of parenteral nutrition admixtures.

Then the results were reviewed to exclude the irrelevant articles, the articles were excluded from the final review if they were not reporting any involvement of the pharmacist in parenteral nutrition practice except only the compounding and preparation of parenteral nutrition admixtures.

Finally there were 19 articles matching the review topic.

The selected articles were classified according to their type as: Commentary review (no. = 1), Descriptive review (no. = 4), Survey (no. = 6), Systematic review (no. = 1), Retrospective studies (no. = 2), Prospective study (no. = 3), Standards of practice (no. = 1), other (no. = 1).

3. Results

The key characteristics of the 19 literatures selected for inclusion in the final review out of 7127 searched published papers are outlined in Table 1.

The search conducted over the previously mentioned databases yielded the following results:

British Medical Journals (BMJ) 310 Papers, Cochrane Library Database 126 Papers, EBSCO 150 Papers, Karger Journals 49 Papers, OVID SP 5252 Papers, SAGE Journals 57 Papers, Science Direct 112 Papers, Scopus Database 145 Papers, Springer link 113 Papers, and Web Of Knowledge 813 Papers.

The included literatures cover a wide range of different pharmacists' involvement in neonatal parenteral nutrition practice, ranging from only compounding the PN admixtures through monitoring and participation in the decision-making process to the point of writing PN orders.

Worth mentioning that the definitions of pharmacist involvement in the PN therapy varies across the literature and in a number of cases, adequate descriptions of the involvement being studied were relatively limited, making comparisons more difficult.

Also it was noticed that there was a wide range of variation related to the quality of literature ranging from prospective studies all the way to just commentary article.

Finally few articles were discussing the pharmacist involvement in neonatal PN ordering process, while most of the articles were focusing on other outcomes and occasionally reporting the pharmacist involvement in PN practice, this finding make it much more difficult to extract these data related to the scope of our review.

4. Discussion

Based on the results of the literature search outlined in Table 1, the focus of the literature was benefits of nutrition support team: (n = 2), variable levels of pharmacist involvement in PN, other than writing PN orders: (n = 9), benefits of pharmacist involvement in PN: (n = 5), pharmacist writing PN orders: (n = 6), and pharmacist writing neonatal PN orders: (n = 2).

From this stratification we noticed that only 2 articles (Ahmed et al., 2004; Mulholland, 2013) were focusing on pharmacist writing neonatal PN orders, and these articles were both surveys, which raise the need for more in-depth research to evaluate the benefits of pharmacist writing neonatal PN orders from the clinical point of view, also we need more clinical trials in this area.

4.1. Benefits of nutrition support team

This was discussed in two articles, the first confirm that the cost of PN will be reduced with the NST (Naylor et al., 2004).

The second article confirms fewer metabolic abnormalities with the NST (Gales and Riley, 1994).

Both articles were focusing on adult cases only.

4.2. Variable levels of pharmacist involvement in PN, other than writing PN orders

Most of the literature lies in this category as there are 9 articles focusing on different levels of pharmacist involvement in PN.

1. Nutrition care plan's implementation and monitoring (Mirtallo and Sacks, 2013).
2. Nutrition consultations (MacLaren et al., 2006; Pedersen et al., 2011).
3. Compounding of PN and are responsible for the logistical aspects and integrity of the PN product lines (Batani et al., 2007).

Table 1 Characteristics of included literatures.

Sr. No.	Author, year	Country	Design	Number of studies/ respondents/patients	Patients Population studied	Limitations	Main outcomes
1	Mirtallo and Sacks (2013)	USA	Commentary review	–	–	<ul style="list-style-type: none"> • Literature design is weak. • Subjective opinion. • Not focusing on neonatal population. 	They proposed a paradigm shift of pharmacy nutrition support to move beyond PN and drug-nutrient interactions and become partners in the interdisciplinary approach to nutrition care plans and offer their assistance with the nutrition care plan's implementation and monitoring of its effectiveness.
2	MacLaren et al. (2006)	USA	Questionnaire survey (Sent by mailings to pharmacy directors of all US institutions with an ICU).	Of 3238 institutions 382 institutions responded corresponding to 1034 ICU's. (Respondents are pharmacy directors)	Adult ICU patients	<ul style="list-style-type: none"> • Not focusing on neonatal population. • Not clear the level of pharmacists' involvement in parenteral nutrition practice. 	Pharmacists provide formal nutrition consultations to ICU's.
3	Naylor et al. (2004)	Australia	Systematic review	11 clinical studies (4 with concurrent controls and 7 with historical controls)	All adult cases The age of patients in the studies ranged between 26 and 93 years	<ul style="list-style-type: none"> • Focusing on the impact of nutrition support team but nothing specific to pharmacist. • Only adult patients. • Only physicians were surveyed. • Not focusing on the pharmacist involvement. • Subjective opinions. • Only the number of units is reported but the actual number of physicians surveyed is not mentioned. 	The data, although limited, support a reduction in costs for patients managed by the TPN team.
4	Ahmed et al. (2004)	UK	Telephone survey of middle grade doctors (Specialist Registrars) working in all neonatal units in England, Scotland, and Wales with 6 or more intensive care cots (total of 57 units).	54 neonatal units out of 57 units responded (95%)	NICU neonates	<ul style="list-style-type: none"> • Only one third of the units involve a pharmacist in the PN prescribing. • In only 3 units the person responsible for ordering PN was a pharmacist. • There is a diverse practice and knowledge with a concerning lack of education in nutrition among the middle grade doctors in England, Scotland, and Wales. • The management of common complications such as sepsis and hyperglycemia are highly variable. • We suggest that the involvement of nutrition teams in all neonatal units would help reduce PN complications. • There is a need for further training of junior doctors in prescribing of PN along with the involvement of pharmacists to ensure safety. 	

5	Batani et al. (2007)	Malaysia	Retrospective study	215 TPN cases	Mixed: <ul style="list-style-type: none"> • Neonates 22.8%, • Pediatrics 11.2%, • Adults 64.6%. 	<ul style="list-style-type: none"> • Not focusing on pharmacists' involvement in PN practice. • Pharmacists were only compounding the PN. • The neonatal population was only 22.8% of cases. 	<ul style="list-style-type: none"> • NST pharmacists have been acknowledged as experts in the compounding of PN and are responsible for the logistical aspects and integrity of the PN product lines. • The finding of this study is proof that the TPN service is associated with a high rate of complications; however, TPN has favorable outcomes. • Electrolyte complications are the main complications encountered by the TPN patients and the rate was 56.5%, which is higher compared with that in advanced countries.
6	Yang et al. (2013)	Korea	Retrospective study	56 neonates in standard protein group, and 53 neonates in high protein group	Very low birth weight neonates (with birth weights < 1500 g and gestational ages between 24 ± 0 weeks and 33 ± 6 weeks)	<ul style="list-style-type: none"> • Not focusing on the pharmacist involvement in PN. • Study focus on the effect of high versus standard protein supplementation 	In this program, the daily amount and calories provided by each major nutrient were automatically calculated from the individualized PN and enteral feeding orders, which were confirmed or modified by a neonatal pharmacist
7	McDermott et al. (1994)	USA	Descriptive review	–	Adults	<ul style="list-style-type: none"> • No statistical analysis provided. • Subjective opinion. • Mixed population and no clear mentioning of neonatal PN. 	The results of the increased influence of pharmacists on the prescribing process included: <ul style="list-style-type: none"> • More appropriate parenteral nutrition therapy, • Earlier transitioning from parenteral to enteral nutrition, • Recognition of staff pharmacists as resources by the physicians, • And increased job satisfaction for pharmacists.
8	Seres et al. (2006)	USA	Web based survey, (Results of the 2003 American Society for Parenteral and Enteral Nutrition Survey)	651 respondents: <ul style="list-style-type: none"> • Pharmacists 32%, • Dietitians 55%, • Nurses 5%, • Physicians 7%, • Others 1%. 	Mixed patients. (No specific mention of the patients' age groups)	<ul style="list-style-type: none"> • Not focusing on neonatal population. • Subjective opinions. • No statistical analysis provided. 	<ul style="list-style-type: none"> • Respondents indicated that dietitians and pharmacists were heavily involved in the order-writing process, either as individuals or as members of a nutrition support service. • The pharmacy was allowed to adjust certain electrolyte additives such as acetate or chloride in 62% of respondent's organizations. • The oversight of the order-writing process was most often the responsibility of the pharmacy (71%).

(continued on next page)

Table 1 (continued)

9	Greenlaw (1979)	USA	Descriptive review	–	Adults	<ul style="list-style-type: none"> • No clear mention of neonatal PN. • Subjective opinion. • No statistical analysis provided. 	<ul style="list-style-type: none"> • The number of patients receiving TPN therapy has increased each year, from six patients during 1976, to 19 patients during 1977 and 54 in 1978. • Of the two preventable complications that developed in these 79 patients, both were quickly resolved by the pharmacist. • Physicians, who, in the past, opted not to place patients on TPN because of lack knowledge or lack of a TPN consultant, now rely on the pharmacist for this service.
10	Mutchie et al. (1979)	USA	Prospective study	Group 1 & group 2, 26 patients in each group, of which, 6 in each neonatal subgroup.	Mixed population; In each group 20 non-neonatal patients, In each group 6 neonatal patients	<ul style="list-style-type: none"> • Small neonatal subgroups sample size (6 patients in each group). • Not clear the monitoring activities done by pharmacists. • No clear mentioning the order writing practices for pharmacists. 	<ul style="list-style-type: none"> • Pharmacist monitoring of TPN reduced the pharmacy's costs and patient charges for TPN and improved the patients' clinical responses to TPN.
11	Mulholland (2013)	UK	Questionnaire Survey, for Pharmacists working in neonatal intensive care units	45 respondents	Neonates in neonatal intensive care units	<ul style="list-style-type: none"> • Subjective opinions • No statistical analysis. • Small sample size. 	<p>The main medicines being prescribed were Parenteral Nutrition (PN) (75%).</p> <p>Benefits of pharmacist prescribing:</p> <ul style="list-style-type: none"> • Improvement in safety was seen as a benefit of pharmacist prescribing, with potential reduction in communication errors (with the pharmacist making a change in medication or dosage, rather than asking a doctor to do it) and the ability to make timely correction of wrong prescriptions. • Pharmacist knowledge of PN and pharmacokinetics were seen to be better utilized with the person advising now also taking the prescribing responsibility. • It was also felt that being a prescriber helped the pharmacist to integrate more into the multidisciplinary team.

12	Ro llins et al. (2008)	USA	ASPEN standards of practice for nutrition support pharmacists	–	Adults, pediatrics, and neonates	<ul style="list-style-type: none"> • Not focusing on neonatal PN. • Not mentioning the benefit of pharmacist writing PN orders. 	<p>Standards of Practice for Nutrition Support Pharmacists:</p> <p>Standard 2.6:</p> <ul style="list-style-type: none"> • The nutrition support pharmacist may write orders for feeding formulations and laboratory tests, and adjust regimens based on response to therapy, changing clinical conditions, and nutrition parameters as delineated by clinical privileges and applicable professional licensure laws.
13	Boullata et al. (2013)	USA	Web-based survey	<p>895 respondents:</p> <ul style="list-style-type: none"> • Pharmacists 54%, • Dietitians 38%, • Nurses 3.5%, • Physicians 3.2%. 	Mixed population and not clearly mentioning the neonatal population	<ul style="list-style-type: none"> • Not focusing on neonatal population. • Subjective opinions. • No statistical analysis. 	<ul style="list-style-type: none"> • 28.3% of respondents reported that a pharmacist was prescribing PN. • The responsibility for communicating the PN prescription when a patient makes a care transition falls primarily to the pharmacist (35%). • Several responses reveal that clarifications are not required because a member of the nutrition support team, most often a pharmacist, writes the orders. • A number of responses indicate that because a pharmacist or nutrition team writes the PN orders, no errors are expected in the PN process.
14	Mirtallo et al. (2009)	USA	Descriptive review	–	Adults	<ul style="list-style-type: none"> • Not focusing on neonatal population. • Subjective opinion. • Not mentioning the benefits of pharmacist writing PN orders. • The pharmacist role in writing PN is not clear. • No statistical analysis. 	<ul style="list-style-type: none"> • The unit-based pharmacist is responsible for initiation and daily management of PN along with the primary service physicians. • The specialty practice pharmacist is responsible for oversight of the PN system throughout the entire health system. <p><i>(continued on next page)</i></p>

Table 1 (continued)

Sr. No.	Author, year	Country	Design	Number of studies/ respondents/patients	Patients Population studied	Limitations	Main outcomes
15	Faber (1991)	USA	Descriptive review	–	Adults	<ul style="list-style-type: none"> • Not focusing on neonatal population. • Subjective opinion. • No statistical analysis. 	<ul style="list-style-type: none"> • The pharmacist serves as a nutritional support therapy consultant to physicians who wish to have their patients evaluated, treated, and monitored by the TPN service. • Six staff pharmacists have completed the training program and are allowed to write TPN orders and conduct TPN rounds. • The program has expanded the clinical roles of the staff pharmacists and has been well received by the medical staff. • The quality assurance monitoring indicates that the service is excellent. • A staff development program was successful in training staff pharmacists to participate in TPN therapy.
16	Strausburg (1995)	USA	Summary of presentation given at the A.S.P.E.N. 19 th clinical congress and was previously published in the program book	–	Adults	<ul style="list-style-type: none"> • Not focusing on neonatal population. • Subjective review. • No statistical analysis. 	<ul style="list-style-type: none"> • Nutrition support responsibilities for clinical pharmacists not solely dedicated to the team: <ul style="list-style-type: none"> • Attend NST rounds on patients in designated patient care area; maintain complete list of all patients in designated patient care area on PN and EN. • Assist NST members and others in designing patient specific NS regimens.
17	Dice et al. (1981)	USA	Prospective study	14 patients in each of the 2 study groups	Neonates at neonatal intensive care unit	<ul style="list-style-type: none"> • Small sample size. • Study was carried on peripheral-vein PN only. • Focusing on pharmacist monitored PN and not on pharmacist ordering PN. 	<ul style="list-style-type: none"> • Pharmacist monitoring of an individualized program of TPN in neonates provided: <ul style="list-style-type: none"> • Greater mean daily weight gain, • Allowed a greater amount of nutrients to be provided, • And was cost effective compared with the use of a standardized solution without pharmacist monitoring.

18	Pedersen et al. (2011)	USA	ASHP national survey (online questionnaire). From the SDI database of 6975 hospitals, a sampling frame of 4898 general and children's medical-surgical hospitals in the United States was constructed, to select the sample of 1968 hospitals	A stratified random sample of pharmacy directors at 1968 general and children's medical-surgical hospitals in the United States was surveyed by Internet and mail	Adults and children	<ul style="list-style-type: none"> • Not focusing on neonatal population. • Subjective opinions. • Focusing on the pharmacist consultation without clear mentioning on pharmacist writing PN. • Not clear the impact of pharmacist involvement. 	<ul style="list-style-type: none"> • 2010 survey results: 52.4% of pharmacy programs provide nutrition consultation, and when provided, more than 99.3% have more than 80% of their consultations accepted by the prescriber. • 2007 survey results: 48.4% of pharmacy programs provide nutrition consultation, and when provided, more than 98.4% have more than 80% of their consultations accepted by the prescriber. • 2004 survey results: 51.1% of pharmacy programs provide nutrition consultation, and when provided, more than 91.6% have more than 80% of their consultations accepted by the prescriber. • 2001 survey results: 46.7% of pharmacy programs provide nutrition consultation, and when provided, more than 76.9% have more than 80% of their consultations accepted by the prescriber.
19	Gales and Riley (1994)	USA	Prospective study	28 adult patients	Adults	<ul style="list-style-type: none"> • Focusing only on adult cases. • Focusing on the impact of nutrition support team (NST) without clear mentioning the impact of pharmacist in PN. 	<ul style="list-style-type: none"> • Patients followed by the NST were more likely to receive adequate nutrition and experience fewer metabolic abnormalities than when TPN therapy was guided solely by a physician. • Evidence demonstrates that physicians have minimal training and experience in this area of nutrition support.

PN: parenteral nutrition; ICU's: intensive care units; TPN: total parenteral nutrition; NST: nutrition support team; NICU: neonatal intensive care unit; ASPEN: American society of parenteral and enteral nutrition; EN: enteral nutrition; NS: nutrition support; ASHP: American society of health system pharmacists.

4. Confirming or modifying the daily amounts of calories provided (Yang et al., 2013).
5. Adjusting electrolytes additives in PN (Seres et al., 2006).
6. The oversight of the order-writing process (Seres et al., 2006).
7. Monitoring neonatal PN (Dice et al., 1981; Mutchie et al., 1979).
8. Attend NST rounds (Strausburg, 1995).
9. Assist NST members and others in designing patient specific NS regimens (Strausburg, 1995).

These diverse activities carried out by pharmacists in the PN practice, if combined, will definitely enable the pharmacist of writing PN orders; either for adults or neonates.

4.3. Benefits of pharmacist involvement in PN

There were 5 articles focusing on the benefits of the pharmacist involvement in PN which are:

1. More appropriate parenteral nutrition therapy (McDermott et al., 1994).
2. Earlier transitioning from parenteral to enteral nutrition (McDermott et al., 1994).
3. Recognition of staff pharmacists as resources by the physicians (McDermott et al., 1994).
4. Increased job satisfaction for pharmacists (McDermott et al., 1994).
5. Reduce the pharmacy's costs and patient charges for TPN (Dice et al., 1981; Mutchie et al., 1979).
6. Improved the patients' clinical responses to TPN (Mutchie et al., 1979).
7. Reduction in communication errors (Mulholland, 2013).
8. More integration into the multidisciplinary team (Mulholland, 2013).
9. Fewer clarifications are required (Boullata et al., 2013).
10. Less medications errors (Boullata et al., 2013).
11. Greater mean daily weight gain for neonates (Dice et al., 1981).
12. Greater amount of nutrients to be provided to neonates (Dice et al., 1981).

4.4. Pharmacist writing PN orders

There were 6 articles focusing on the pharmacist writing PN orders but in all of them the patients were of mixed population and/or it was difficult to extract the data for neonates.

1. In the web based survey by Seres et al. (2006), pharmacists were heavily involved in PN writing process (Seres et al., 2006).
2. In the review by Greenlaw (1979), the pharmacist is responsible solely of writing PN orders (Greenlaw, 1979).
3. This is from the ASPEN standards of practice for nutrition support pharmacists stating that nutrition support pharmacist may write orders for feeding formulations (Rollins et al., 2008).
4. In the survey by Boullata et al. (2013), 28.3% of respondents reported that a pharmacist was prescribing PN (Boullata et al., 2013).

5. In the clinical observation review by Mirtallo et al. (2009), the unit-based pharmacist was responsible for initiation of PN (Mirtallo et al., 2009).
6. In the descriptive review by Faber (1991), six pharmacists completed the training program and were allowed to write PN orders and conduct PN rounds (Faber, 1991).

We noticed that all the 6 articles were either reviews or surveys or poster presentation, and no single clinical trial was available to judge the practice of pharmacist writing PN orders; which again raise the need for good quality clinical research on this area.

4.5. Pharmacist writing neonatal PN orders

Finally we reach to the articles covering the exact scope of this literature review, and there were only 2 surveys in this group.

1. In the first survey by Mansoor et al., 2004, only three of the surveyed neonatal units reported that the person responsible for ordering PN was a pharmacist (Ahmed et al., 2004).
2. In the second survey by Mulholland (2013), he reported that the main medications being prescribed by the respondent pharmacists ($n = 45$), were parenteral nutrition (75%) (Mulholland, 2013).

But the limitations for both articles are the lack of objectivity and small size of the surveys.

Worth mentioning that in the study by Batani et al. (2007), which was carried out at USM, Malaysia (Batani et al., 2007), the rate of electrolyte and metabolic complications was 56.5% which is higher compared with that in developed countries, also in this study the pharmacist role was only compounding of the PN admixtures (Batani et al., 2007).

While in the study of Gales and Riley (1994), they demonstrated that adding a pharmacist to the nutrition support team with direct interventions in the nutritional care plan, will reduce the metabolic and electrolyte complications associated with parenteral nutrition therapy (Gales and Riley, 1994).

This could make us assume that in the study of Batani et al. (2007). If the pharmacists had better role in the PN process this could have reduced the metabolic and electrolyte complications encountered.

5. Conclusion

Overall, the review presents the up-to-date status of the most recent analysis being undertaken on the topic of pharmacist involvement in the parenteral nutrition order writing practices and more specific in the neonatal population over the period from 1979 to 2013.

The overall impression is that the practice of pharmacist writing neonatal parenteral nutrition orders already exists, but still limited if compared with the practice pharmacist writing adult parenteral nutrition orders which is much more established in many countries.

It is very difficult to assess the usefulness of the practice of pharmacist writing neonatal parenteral nutrition orders in the view of lack of good quality clinical trials evaluating this practice in the real life, there was no single clinical study evaluating this practice, as we were able to retrieve only two surveys.

Nevertheless, despite the wide variation in literature types, characteristics and quality, there are consistent patterns across all the reviewed literature that competencies of the pharmacist in this field are well represented, which make it very important to carry out good quality clinical studies to assess the clinical benefits of the pharmacist involvement in writing neonatal parenteral nutrition orders.

Finally, based on all these findings, we are currently conducting a prospective clinical study with historical cohort control – at Prince Salman Northwestern Armed Forces Hospital, Tabuk – to evaluate the impact of clinical pharmacist as a neonatal PN prescriber, this impact will be judged through the study outcomes as reducing the metabolic and electrolytes complications and increasing the mean daily weight gain during PN therapy and reducing the average number of days of PN till enteral feeding is achieved.

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