INTRODUCTION

Parenteral nutrition (PN) is a life saving and high alert therapy indicated for patients who cannot meet their needs enterally. Its use is also associated with a risk of bloodstream infection (Ayers et al., 2014). This complex therapy aims to improve clinical outcomes while mitigating the potential risks for adverse events. It is a team responsibility of pharmacists, physicians, pharmacy technicians, nutritionists, and nurses, to assure that PN is prescribed, verified, compounded, stored, monitored and appropriately administrated based on internal policies in the respective institution when PN is the optimal/preferred route of nutrition support for their patient. Compounding in a hospital follows a decision considering multiple aspects. The effectiveness of a tailored product, its safety and economic outcomes are to be evaluated. It is a strategic decision to compound or purchase outsourced compounded PN or multi chamber bag from the market. Compound PN in-house or outsource or when to use multi chamber bag parenteral nutrition (MCB-PN) is a multi stakeholder decision considering quality,
cost, provision, expertise, effectiveness, safety and automation. MCB-PN (manufactured by pharmaceutical companies, commonly known as premixed or standardized PN) products are standardized solutions commercially available. In contrast, the compounded PN solutions are tailored to the patients’ specific requirements and are prepared in hospital pharmacies following USP chapter <797> procedures and other compounding standards (Boulatta et al., 2014). Guidelines have been published to use automated compounders in the preparation of PN (Raimbault et al., 2012). In the UAE, there are no national PN guidelines to follow. Healthcare institutions need guidance for care delivery and system intelligence to determine the most appropriate types of PN formulation for their patient population. A decision on the choice of MCB-PN or compounded PN needs evaluation of internal and external factors.

**MATERIALS AND METHODS**

A strength, weakness, opportunities, threats analysis was conducted using mixed data collection methods; surveys, interviews and literature review. PN stakeholders in the UAE were contacted through the intravenous and parenteral nutrition network and the IVPN conference 2019. As per 2017 statistics released by UAE federal statistics and competitive authority, there were 45 healthcare providers in the government (public) sector and 98 healthcare providers in the private sector. It includes clinics, hospitals, and several primary healthcare centers (U.ae. Healthcare Providers, 2020). Opinion leaders from twelve different hospitals handling both MCB-PN and Compounded PN were surveyed and interviewed. Data were collected from chief pharmacy officers, physicians, consultant neonatologists, senior pediatricians, head of ICU, head of NICU, nutritionists and nurses.

The survey consisted of 6 questions. Questions 1-5 were to obtain the background of PN use at UAE hospitals. These included the types of PN product, patient population, type of compounding and years of experience handling PN. The last question of the survey was about addressing any challenges related to PN. Another survey focused on decision making strategy on PN modality choice was conducted in hospitals handling both MCB-PN and PN compounding. These hospitals with PN handling experiences were visited to conduct an in-depth individual interview with PN professionals. The individual interview is conducted by visiting the health professionals practice site, including physicians (consultant neonatologist, senior pediatrician, head of ICU, head of NICU), nutritionists, nurses, and pharmacists. Information collected from health professionals on their patients was not specific for each patient, but general observation of health professionals on their patients considering their preference in choosing MCB-PN vs compounded PN in specific characteristics which might play a role in the decision-making process.

The analysis uses a provider perspective. A SWOT analysis table and recommendations were prepared based on survey and interview inputs and reviews of PN literature. Recommendations have been categorized using the GRADE system to indicate the level of evidence and strength of agreement reached for each statement (Lowson, 2015). GRADE recommendation system used was as follows;

- 1A: Strong recommendation; High-quality evidence
- 1B: Strong recommendation; moderate-quality evidence
- 1C: Strong recommendation; Low-quality evidence
- 2A: Weak recommendation; High-quality evidence
- 2B: Weak recommendation; moderate-quality evidence
- 2C: Weak recommendation; Low-quality evidence

The SWOT analysis and recommendations were reviewed by two additional experts in two leading hospitals in the UAE before circulating for further feedback. Ethics approval was taken from the Institutional Review Board of Gulf Medical University.

**RESULTS AND DISCUSSION**

SWOT analysis (as shown in Table 1) and recommendations on the choice of the MCB-PN or compounded PN were prepared. The evidence available from PN guidelines globally and local experiences was incorporated in the preparation of the analysis. Recommendations developed from the SWOT analysis is categorized using the GRADE system) (Guyatt et al., 2008). It is recommended to prescribe the most appropriate nutrition modality for the patient. Compounded PN is the first choice in critically ill patients with comorbidities, complicated cases of metabolic disorders, and neonates. Accordingly, the MCB-PN has no place in the intensive care unit (ICU) for unstable cases, neonates intensive care unit (NICU) and pediatric intensive care unit (PICU)
Table 1: SWOT analysis of the choice of multi-chamber bag and compounded PN in UAE.

| SWOT          | Multi-chamber bag PN                                                                 | Compounded PN                                                                 |
|---------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Strengths     | 1. Prolonged shelf-life (Stability), do not require refrigeration.                   | 1. Ready to use (no further manipulation required)                             |
| (internal)    | 2. Less costly in limited usage                                                     | 2. Suitable for individualized clinical outcomes, more scope for adjustments  |
|               | 3. Low prescribing errors Easy to use and timesaving                                 | based on monitoring                                                             |
|               | 4. All in one formulation (3 in 1)                                                  | 3. The only option for infants and pediatrics use                              |
|               | 5. Offer a means of PN, particularly in the absence of a nutrition support team.    | 4. In-house compounded PN is less costly and more profitable in high quantity  |
|               |                                                                                     | usage.                                                                        |
| Weaknesses    | 1. The volume of the bag is fixed.                                                  | 1. Time-consuming                                                              |
| (internal)    | 2. More manipulation required to adjust micronutrients                              | 2. More workload                                                               |
|               | 3. Limited products are available in the UAE.                                       | 3. Prescribing errors/ calculation errors/ compounding errors                   |
|               | 4. Not utilizing the presence of experts in PN compounding.                         | 4. Stability issue and require refrigeration                                     |
|               | 5. More metabolic complications (e.g., hyperglycemia, hypertriglyceridemia, or      | 5. More risk for bloodstream infections                                          |
|               | electrolyte imbalances)                                                             | 6. Fully responsible for the defective products                                |
| Opportunities | 1. Market shortage of components in individual PN                                    |                                                                               |
| (external)    | 2. Home PN needs                                                                    |                                                                               |
|               | 3. A source of PN while planning a limited resource healthcare facility              |                                                                               |
| Threats       | 1. Limited published data demonstrating clinical benefits with standardized PN    | 1. Clinical consideration of patient requirements (e.g., comorbidities, critically ill cases, infants and neonates and biochemical response) |
| (external)    | solutions for pediatric patients, guidelines support compounded PN for pediatrics | 2. Automation and integration between prescribing and Automated compounding    |
|               | 2. Not able to attract customers who need individualized PN                          | machine                                                                        |
|               | 3. Provider’s preference towards patient-tailored nutritional intervention          | 3. Sell compounded PN to other hospitals.                                      |
|               |                                                                                     |                                                                               |

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Compounded PN for patients who need tailored nutrient intake to improve patient outcomes (Grade 1A) (Ayers et al., 2014; Boullata et al., 2014). Choose MCB-PN if the following considerations are a priority: stability, less workload, fewer errors, and no refrigeration need. The availability of the MCB-PN may improve patients nutritional management in emergencies, particularly during the evenings and weekends, when compounded PN formulations may not be prepared in optimal conditions (Grade 2B) (Gervasio, 2012).

Choose MCB-PN to minimize misinterpretation of orders, calculate errors, and decrease compounding errors, if these cannot be controlled with compounded PN (Grade 2B) (Raimbault et al., 2012). Manipulate the MCB-PN to adjust micro nutrients (e.g., vitamins and electrolytes) up to the manufacturer’s limits (Grade 2C) (Hospital Pharmacy Europe, 2020). Be more confident in the use of compounded PN. The majority of pharmacists prefer MCB-PN as it is easy to use and error-free. While the physicians prefer the customized, compounded PN modality (Grade 2C). All who reviewed the SWOT analysis and recommendations found it relevant to their hospital’s pharmacy operations. Most respondents considered this SWOT analysis and recommendations comprehensively covering all aspects of MCB-PN or compounded PN choice.

In the UAE, parenteral nutrition practices are similar to ASPEN guidelines. Thus, the recommendations were drafted based on ASPEN guidelines as a prototype. Utilizing a combination of both MCB-PN and compounded PN could reduce pharmacy workload and costs while maintaining flexibility. Outsource compounding is considered when the number of PN orders is deficient and staff competency/resources are limited. However, some of the organizations have a delay in the supply of outsourced PN. Compounded PN is most suitable for patients with rapidly changing requirements such as neonates, PICU, and ICU critically ill patients. Automation and integration between prescribing and automated compounding systems streamlines the labor-intensive process. Automated compounding systems save money in allowing hospital pharmacies to produce compounded PN with safety, consistency, and lower total product cost (Raimbault et al., 2012). This improves accuracy and efficiency and minimizes the need for manual additions, reducing microbial and particulate contamination risk. This makes it possible to compound many bags and probably sell compounded PN to other hospitals. Market shortage of components or other resources to individual compound PN shall create an opportunity for using MCB-PN as an alternative in

Train all PN compounding personnel, including technicians, on the proper techniques and prevent errors and harm (Grade 1B) (Fisher and Opper, 1996; Parent et al., 2016). Mitigate errors of compounded PN through automation and integration systems between prescribing and automated compounding machine as it is a highly specialized product with the potential for errors in ordering, transcribing, preparation, labeling and administration (Grade 1B) (Flynn et al., 1997; Hilmas and Peoples, 2012). Choose MCB-PN as an alternative (with limitations) when there is a market shortage of components or other resources to individual compound PN (Grade 1B) (Chhim and Crill, 2015). Provide MCB-PN for Home PN (HPN) support. Patients receiving long-term PN, often started at the hospital with compounded PN and then administered at home after stabilizing the case and are generally provided with MCB-PN due to the stability and easy administration (Grade 1C) (Bonnes et al., 2019).

Take benefit of the design of (3-in-1) MCB-PN to activate only the peel seal between the amino acids/electrolytes and glucose chambers, leaving the peel seal between the amino acids and lipid chambers intact (Grade 1C) (Hospital Pharmacy Europe, 2020). In the UAE, adult MCB-PN formulations are available, but not pediatric. The need for pediatric standard formulations in the UAE market needs to be assessed (Grade 1C) (Miller, 2009). Choose the PN modality without considering the duration of PN therapy, either MCB-PN or compounded PN (Grade 1C). Involve patients in deciding on the choice of MCB-PN or compounded PN (Grade 1C). Choose 3-in-1 MCB-PN when reduced inventory (infusion pump, IV tubing, and related supplies) and less nursing time is essential (Grade 2A) (Yu et al., 2017; Pichard et al., 2000). Automate compounding when possible to ensure patient safety and help hospitals cut costs and save money and initiate selling compounded PN to other hospitals (Grade 2A) (Pichard et al., 2000; Traeger, 1986).
adults and pediatrics (age range 1–18 yrs.) (Chhim and Crill, 2015). MCB-PN is a close stable system, ready to use, and does not require refrigeration, making them a useful option for stable home PN patients. MCB-PN may not be appropriate for all patients. The volume of the bag is fixed. Thus, MCB-PN may not be a suitable option for fluid restricted patients. Both MCB-PN and compounded PN are available in UAE to administer through peripheral or central lines. Across UAE hospitals, the central line is the main route of administration of PN solution to avoid the risk of thrombophlebitis (Ayers et al., 2014). Adult MCB-PN formulations are available, but pediatric products are limited in the UAE. A broader selection of MCB products is available in Europe, the US, and some other parts of the world compared with the UAE. Exclusive use of MCB-PN has the risk of metabolic complications (e.g., hyperglycemia, hypertriglyceridemia, or electrolyte imbalances) compared to patient-tailored, compounded PN (Gervasio, 2012).

Several studies showed that the use of MCB-PN is a less costly alternative to compounded PN (Bigioni et al., 2014; Turpin et al., 2011). Compounded PN is considered less costly and more profitable compared to MCB-PN if more bags per day are used, so it seems reasonable to use compounded PN bags in hospitals with a high volume of patients. In small hospitals, MCB-PN is more advantageous. However, the PN’s profitability should not impact the healthcare professional’s decisions on the choice of MCB-PN or compounded PN despite PN therapy. The compounded PN is usually under the general exclusion of health insurance plans and has limited insurance reimbursement. The payments by the patients are necessary. The Dubai Health Authority and the Department of Health in the UAE have adopted the International Refined Diagnosis Related Groups (IR-DRGs) model for inpatient hospital payment. So, when PN is administered in the hospital, its payment is included in the DRG. No justification for using it is needed (Mihailovic et al., 2016). The SWOT analysis and recommendations of choice of MCB-PN and compounded PN in UAE are well-received. The impact of it needs to be studied on how useful it is to start, stop, scale-up or scale-down MCB-PN and compounded PN in UAE.

CONCLUSIONS

This SWOT analysis comprehensively covers relevant factors on the choice of MCB-PN and compounded PN in the UAE. Recommendations derived from the SWOT analysis are helpful in decision-making. Major PN providers in the country received this guidance well. Evaluation of the impact of this guidance and further modifications are planned in the future.

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Conflict of Interest

The authors declare that they have no conflict of interest for this study.

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