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Current Specialist Awareness on Ultrasound Use for Central Venous Catheterization

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Obtaining central venous access is a fundamental clinical skill for managing patients in a wide variety of clinical situations. The role of routine portable Ultrasound (US) in the placement of Central Venous Catheters (CVCs) has been debated and some important evidence-based guidelines supporting the liberal use of ultrasound for this specific procedure have been published.¹–³ The use of ultrasound to help on central venous catheterization has shown to improve success rates with reduced complications, however the ultrasound has not been adopted worldwide for this specific end. Also, specialists’ response to new publications on this subject is unknown. It is our feeling that, although many manuscripts have already proven that the US is safe and effective, its use is not routinely observed in a daily practice.

With this observation made, a question to validate this affirmative has blossomed and these authors decided to post it on a scientific social network, so we could be able to investigate current opinion and awareness from worldwide physicians from different specialties on ultrasound use for central venous catheterization. Throughout a specific scientific social network (researchgate.net) composed by 9 million members up-to-date from different professional areas including medicine, the question: “Is ultrasound an essential tool for placing central venous lines?” was raised. One of the website tools is a section where members perform questions and get answers on specific subject from different worldwide scientists. After 500 days online, answers were no longer accepted and the question placed offline for analysis. The following variables were analyzed: number of answers, number of countries answering the question, number of institutions involved on the query, quality of responders (based on published articles/citations and impact factors), specialties and opinions.

Two-hundred and twenty-four answers were registered. Three answers were excluded: two from registered nurses and one from a veterinarian. In total, 221 physician’s answers were analyzed. Thirty-six countries and 114 different institutions participated answering the proposed question as represented in Table 1. All responders were analyzed regarding their academic activity. A mean of 21.5 articles published (average of 28.39 impact factor) were related to responders (SD±37.4) with 85.5(SD±427.62) average of citations.

Regarding all specialties 61.66% were anesthesiologists, 10% ER physicians, 7.5% surgeons, 5.83% critical care specialists, 5% pediatricians, 3% GI specialists and the remaining neonatologists, cardiologists, hematologists, radiologists, orthopedics and general practitioners summed 4.98% all together.

In regards to the specific question “Is ultrasound an essential tool for placing central venous lines?” an average of 54% of responders answered yes (46% otherwise). Among the top five specialties that more participated on this research, ER physicians and pediatricians are those that most likely believe that the ultrasound is an essential tool for placing CVCs (50%), followed by surgeons (44.4%), critical care specialists (42.85%) and anesthesiologists (41.89%).

Obtaining central venous access is a fundamental clinical skill for managing patients in a wide variety of clinical situations. The role of routine portable Ultrasound (US) in the placement of Central Venous Catheters (CVCs) has been debated and some important evidence-based guidelines supporting the liberal use of ultrasound for this specific procedure have been published.¹–³ The use of ultrasound to help on central venous catheterization has shown to improve success rates with reduced complications, however the ultrasound has not been adopted worldwide for this specific end. Also, specialists’ response to new publications on this subject is unknown. It is our feeling that, although many manuscripts have already proven that the US is safe and effective, its use is not routinely observed in a daily practice.

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| Country          | Institution                                      | Country          | Institution                                      |
|------------------|--------------------------------------------------|------------------|--------------------------------------------------|
| Argentina        | Hospital Durand                                 | Iran             | Tehran University of Medical Sciences            |
|                  | University of Sydney                            |                  | Shahid Beheshti University of Medical Sciences   |
|                  | University of New South Wales                   |                  |                                                 |
|                  | St John of God Healthcare                       |                  |                                                 |
|                  | Royal Flying Doctor Services                    |                  |                                                 |
| Australia        |                                                 | Japan            | Japan Community Health Care Organization         |
| Brazil           | University of Campinas                           | Jordan           | King Hussein Medical Center                      |
| Canada           | University of Ottawa                            | Morocco          | Université Ibn Tofail                           |
|                  | SickKids - Toronto                              |                  |                                                 |
| China            | Jinhua Municipal Central Hospital                |                  |                                                 |
|                  | Chinese University of Hong Kong                 |                  |                                                 |
| Croatia          | University Clinical Hospital Center              | Peru             | Hospital Regional Docente de Trujillo           |
|                  | Klinički bolnični centar Rijeka                 | Poland           | Children’s Memorial Health Institute             |
|                  | Varazdin General Hospital                       |                  |                                                 |
|                  | University Hospital Centre Zagreb               | Portugal         | Coimbra University Hospital Center              |
|                  |                                                 | Qatar            | Hamad Medical Corporation                       |
| Czech Republic   | Charles University of Prague                    | Romania          | Universitatea de Medicina si Farmacie Grigore T. P. Institutul Clinic Fundeni |
| Denmark          | Aarhus University Hospital                       |                  |                                                 |
| Egypt            | Zagazig University                               | Saudi Arabia     | Prince Sultan Military Medical City             |
|                  |                                                 |                  | King Faisal Specialist Hospital and Research Center |
| France           | Hôpital Universitaire Necker                     | Singapore        | National University Health System               |
|                  | Centre Hospitalier de Saint-Quentin             |                  |                                                 |
|                  | Clinique Du Parc Saint Lazar                    | Spain            | Hospital Universitario La Paz                   |
|                  | Clinique Saint Augustin                         |                  | Onkologikoa                                     |
|                  | Institut de Radiologie de Neuchâtel             |                  | Hospital Universitario Miguel Servet            |
|                  | Clinique Hospitalier de Fontainebleau           |                  | Hospital Universitari i Politècnic la Fe       |
| Germany          | Elisabeth-Krankenhaus                            | Sweden           | University of Valencia                           |
|                  | University of Cologne                           |                  |                                                 |
|                  | Herz- und Diabeteszentrum Nordrhein-Westfalen   | Turkey           | Gulhane Military Medical Academy                |
| Greece           | General Hospital Preveza                        |                  | Haseki Training and Research Hospital            |
|                  | General University Hospital of Larissa           |                  | Necmettin Erbakan Universitesi                  |
| Hungary          | Kaposi Mór Oktató Kórház                         | United Arab Emirates | Cleveland Clinic Abu Dhabi                    |
| India            | All India Institute of Medical Sciences Rishkesh|                  | Tawam Hospital                                  |
|                  | Madras Institute of Orthopaedics and Traumatology|                  | NMC Healthcare LLC                              |
|                  | Sanjay Gandhi Post Graduate Institute of Medical Sciences|                  | Specialized Medical Care Hospital               |
|                  | Institute of Medical Sciences                   |                  |                                                 |
|                  | Postgraduate Institute of Medical Education and Research|               |                                                 |
|                  | Sanjay Gandhi Post Graduate Institute of Medical Sciences|             |                                                 |
|                  | Global Hospital                                 |                  |                                                 |
|                  | Columbia Asia Hospital - Mysore                  |                  |                                                 |
|                  | Reliance Industries Limited                      |                  |                                                 |
|                  | B. J. Medical College                            |                  |                                                 |
|                  | Kingsway Healthcare                              |                  |                                                 |
|                  | AllIMS Bhopal All India Institute of Medical Sciences|                  |                                                 |
|                  | Institute of Liver and Biliary Sciences          |                  |                                                 |
|                  | Pondicherry Institute of Medical Sciences        |                  |                                                 |
|                  | Lady Hardinge Medical College                    |                  |                                                 |
| United States of America | Washington University in St. Louis |                  |                                                 |
|                  | University of Miami Miller School of Medicine    |                  |                                                 |
|                  | Medical College of Wisconsin                     |                  |                                                 |
|                  | Tampa General Hospital                           |                  |                                                 |
|                  | University of California                         |                  |                                                 |
|                  | University of Texas Health Science Center        |                  |                                                 |
|                  | Vail Valley Medical Center                       |                  |                                                 |
|                  | Greater Baltimores Medical Center                |                  |                                                 |
|                  | Mayo Foundation for Medical Education and Research|               |                                                 |
|                  | University of Nebraska Medical Center            |                  |                                                 |
|                  | Hartford Hospital                                |                  |                                                 |
|                  | University of South Carolina                     |                  |                                                 |
|                  | Loyola University Medical Center                 |                  |                                                 |
|                  | University of Pittsburgh                         |                  |                                                 |
|                  | Wayne State University                           |                  |                                                 |
Ten responder opinions were relevant to mention, as follows:

1) Ultrasound is the gold standard for the placement of CVCs - 56.34%.
2) US device for CVC placement should be preferred if US is available - 53.17%.
3) Physicians should be trained in both anatomic landmark technique (AL) and US technique (US) - 46.82%.
4) Residents must be taught into both techniques AL and US - 44.44%.
5) US use should be mandatory - 42.85%.
6) US technique is difficult to use on subclavian vein - 11.9%.
7) Physicians should be free to use whatever technique he/she thinks is better for their patients - 11.11%.
8) Physicians should learn first anatomic landmark technique before start handling the US for this matter - 10.31%.
9) The US learning curve is long - 4.76%.
10) Physicians used to anatomic landmark technique have trouble to learn the US technique - 1.58%.

This brief opinion report brings to light whether specialists are aware of the use of ultrasound on placing CVCs. Many studies were published reinforcing the use of ultrasound for this purpose proving to be safe and effective. Even though there are a number of recent papers stressing the use of ultrasound as an essential tool in placing CVCs, this device is not available at all institutions and it is not currently the standard of care worldwide.

The question on how physicians from different specialties worldwide are aware about using the ultrasound for this specific purpose has aroused, creating an interesting field of investigation on current opinion of specialists on this specific matter. One important need for these authors was to determine whether or not the responders group are involved in academic activities. The meaning of this is that if the majority of responders are really involved in academic activities, doing research and publishing, then we were probably dealing with a very special high-level group of specialists. This is the reason why we also searched on responders’ publications, impact factor of publications and citations. To the end of this very first section of the study we realized that we were dealing with a strong group of specialists involved with many publications of good power. An average of 21.5 manuscripts were related to each responder with an impact factor average of 28.39 confirming that our group of responders are all involved in academics and indeed are experts on the subject. Fifty-four percent of specialists believe that the ultrasound is an essential tool for placing central venous lines. Fifty percent of emergency physicians and pediatricians were skeptical in affirm that the ultrasound is essential for the procedure in question. Not too far from this number were surgeons, intensivists and anesthesiologists, dividing the population of specialists on the opinion that ultrasound is or is not an essential tool for obtaining central lines. The point that these two authors were not able to clarify is why specialists are divided on the use of ultrasound for this purpose, even though literature enforces safety and efficacy with fewer complications with the use of this modern point-of-care device?

Following this rationale, only 56% of responders expressed that the use of ultrasound for determining a CVC is the standard-of-care. In the same way, only 53.7% affirm that ultrasound should be preferred when available. In a time of evidence-based medicine shouldn’t we expect a higher number of physicians defending the use of ultrasound? Maybe, because of ultrasound for determining CVC and ultrasound point-of-care is something relatively new in medicine, adoption for this new technique including its learning curve and training would be a hassle for experienced physicians to shift from one technique to another. The answer is no. Based on this research only 1.58% expressed in the discussion that learning another technique would be an issue. 10.31% of physicians expressed that should learn first anatomic landmark technique before start handling the US for this matter. In the other hand, around 90% of this selective group of responders do not agree that a physician should use whatever technique he or she thinks is the best for their patients,
suggesting that a protocol must be followed. In order to that, some training must happen in any stage of medical career but only 44.44% of these opinion leaders defended in the discussion that residents must be taught into both techniques. Many questions and debates are arising on literature regarding training for central venous line access and learning both techniques during residency looks reasonable, in contrast to specialists’ position on this research where 66% of responders did not expressed any argument for residents training in both techniques. Our opinion is that both residents and physicians must be prepared for the use of ultrasound or not depending on the situation or where he is working. In a critical scenario the quick use of the ultrasound may be difficult due to patient’s severity and anatomic landmark should be stimulated. By the other hand, ultrasound should be the first option when available, in agreement with responders (58%) that stated that ultrasonography should not be mandatory. A physician should have adequate proficiency in the landmark technique as in the ultrasound technique but the evidence favors for the ultrasound technique. The fact that a certain percentage of people agreed with the same opinion does not mean that the others disagree with them; therefore, this dataset could estimate the real opinion from responders but was not precise about it.

With this brief opinion report it is clear to us that in a time of evidence-based medicine there are still some controversies that need to be addressed regarding the use of ultrasound for placing CVCs, including a uniform opinion on training, protocols and finally broad use of a proven benefic device. The pros and cons on using or not the ultrasound for the subject herein discussed maybe never end; however, there are so strong evidences that support its use in order to avoid not only mechanical complications but infectious complications and thrombosis that the use of US seems in fact the best option.

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High Fidelity Simulation Improves Provider Confidence During ACLS Training Even Among Experienced Staff: Are We Missing an Opportunity?

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ABSTRACT

Background: Advanced Cardiac Life Support (ACLS) resuscitation requires rapid assessment and intervention. It is unclear, however, whether high fidelity simulation improves confidence in providers who are experienced as most simulation training focuses on new graduates or hires. We tested the hypothesis that practicing providers undergoing high-fidelity simulation of cardiopulmonary arrest scenarios will express greater confidence in ACLS skills.

Methods: We conducted a prospective cohort study at an urban level 1 trauma center from January to October, 2011 with a convenience sample of nurses, nurse practitioners, and physicians. They participated in high-fidelity (Laerdal 3G) simulation sessions of cardiopulmonary arrest about 3 months apart. Each session included two scenarios and lasted 30 minutes, including debriefing. We recorded demographics and confidence on a validated 5 point Likert scale confidence measurement tool before and after each session. Responses ranged from not at all confident (1) to very confident (5) in: recognizing signs and symptoms, appropriately intervening, and evaluating intervention effectiveness in cardiac and respiratory arrests. Descriptive statistics, paired t-tests, and ANOVA were used for data analysis. Sensitivity testing evaluated subjects who completed their second session at 6 months rather than 3 months.

Results: Sixty-five subjects completed consent, 35 completed 1 session and 23 completed at least 2 sessions with no missing data. Ninety-two percent were registered nurses, median clinical experience was 11-15 years, and 59% were from an intensive care unit. Provider confidence increased significantly after a single session. There was a trend for further increased confidence with an additional session and the increased confidence was maintained for at least 3-6 months given the sensitivity analysis. The number of cardiopulmonary arrests directly participated in...
Confidence, while poorly understood, may be a key ingredient in time critical resuscitation situations. For example, the American Heart Association (AHA) recently revised their guidelines to minimize pulse checks because they found significant delays in starting chest compressions as providers lacked confidence in their ability to determine the presence of a pulse. Even if the correct decision to start cardiopulmonary resuscitation (CPR) is eventually made (knowledge), the delay (poor confidence) may influence outcomes. What is unclear is how simulation training impacts the confidence of providers with variable levels of experience since most simulation research focuses on new hires or new graduates.

Simulation allows practice and learning in a safe and structured environment. The Critical Care Societies Collaborative (CCSC) recommends examining the value and effective use of simulation in the education of critical care providers as part of its agenda to establish critical care research priorities across diverse specialties. While simulation can be exciting, interactive and collaborative learning, we sought to determine whether this translates into increased confidence.

It seems clear that simulation can increase knowledge. Although studying students, both Bruce and Corbridge found simulation improved management scores. Nevertheless, there is an impression among some experienced providers that simulation is only useful for novices who lack clinical familiarity. Simulation technology may be accepted variably based on generational differences.

Confidence may be different from knowledge. When Alinier et al studied the effects of scenario-based simulation training on nursing student’s clinical skills, they found that mean performance scores in the simulation training group were higher than the control group with no simulation training. However, there was no statistical difference in the student’s perception of confidence in working in a technical environment.

Conversely, Mould et al used a before and after test design to measure nursing student’s self-reported confidence after a series of simulation sessions and found that the scenarios were effective in improving student’s confidence in handling critical care situations. Perhaps, whether simulation training specifically improves, confidence, knowledge, skill, or empowerment depends on how coaching/punitive the teaching environment remains.

Confidence, technical skill and leadership may not be equivalent and might require different education. Hunziker et al found greater CPR quality as measured by delays to initiation and hands off time in medical students who received leadership education compared to CPR technical skills education. Similarly, Yeung et al found improved team CPR quality in teams led by more experienced providers and those with specific leadership training. Wallace et al showed that CPR quality is associated has been associated with actual patient outcomes. Buckley et al showed that during post training clinical care, graduate nurses reported the most useful aspects of simulation training were scenario debriefing and assertiveness training. Perhaps most importantly, Andreatta et al showed that simulation correlated with improved pediatric cardiopulmonary arrest survival rates.

There is limited research regarding experienced health care provider confidence and the use of simulation. Rather than a defense of high-fidelity simulation, this research study sought to fill the knowledge gap by specifically examining the relationship between simulation and experienced health care provider confidence. We hypothesized that practicing health care providers who undergo high fidelity simulation will express greater confidence during cardiopulmonary arrest training.

METHODS

Study Design, Setting and Population

This was a prospective cohort study conducted at a tertiary care Level 1 Trauma Center October 2010 and October, 2011. Physicians and nurses (Registered, Licensed or Advanced Practice) were included if willing to participate in at least one of four thirty minute simulation sessions held about three months apart, although participation in two was preferred. Subjects were excluded if they did not plan to be at the hospital for the duration of the study.

Study Procedures

Subjects were recruited via hospital broadcast email, flyers, and word of mouth and scheduled to simulation sessions in half hour blocks to minimize crowding, keep the number of subjects per scenario similar, and allow those coming from units to arrange temporary cross coverage. Sessions were held quarterly and subjects were asked to attend two of them. During sessions, participants used the high fidelity Laerdal 3G simulator to work through two standardized American Heart Association (AHA) Advanced Cardiac Life Support (ACLS) scenarios of either cardio or pulmonary distress. Scenarios were changed for each session day. Study investigators created a supportive learning environment during sessions that included an orientation to the simulator and after-action debriefs that were educational/
coaching rather than punitive. The debriefing style encouraged critical reasoning and was similar to that already incorporated by the Clinical Nurse Educators at the institution. The same investigators administered all sessions. Subjects had to attend a minimum of one session to be included in data analysis. Subjects were not paid for participation. The study was Institutional Review Board approved and participants completed written informed consent.

Outcome Measures

Before and after each session, participants completed the Health Care Provider Confidence During Cardiopulmonary Arrest Scale, modified with permission from the validated critical care Self-Confidence Scale to measure confidence specifically during cardiopulmonary resuscitation situations. The modifications were assessed for clarity and content validity by a panel of critical care, emergency medicine and nursing educators (see Table 1). Participants could write free text comments. The study team did not track the clinical success of each resuscitation scenario. The primary outcome was the impact of high fidelity simulation on provider confidence measured before and after each session. The secondary outcomes were provider confidence associations between sessions and subject demographics.

Data Analysis

Descriptive statistics were used to evaluate demographics. Paired t-tests and analysis of variance (ANOVA) were used to compare means where appropriate. Sensitivity testing was used to evaluate the impact of subjects who completed their second session at six months rather than three months. Data was analyzed using Statistical Package for the Social Sciences (IBM, Armonk, New York, USA).

RESULTS

Thirty-five participants fully completed at least one session, 23 completed at least 2 sessions, 5 completed three sessions, and one completed all four sessions. The convenience sample was 95% female with a median age range of 41-50 years. The median range of clinical experience was 11-15 years, with 6-10 years in their current role and 97% worked with adults. Ninety-two percent were RNs, and there were one each NP, MDs, and LPNs. All were basic life support (BLS) certified and 2 were BLS instructors. Eighty percent were ACLS certified and 1 was an ACLS instructor. Seven (19%) were trauma nurse core course (TNCC) certified and 2 were advanced trauma life support (ATLS) certified; two were pediatric advanced life support (PALS) certified. None were PALS instructors.

Most study participants, 20 (59%), worked primarily in an intensive care unit (ICU); 6 (16%) worked in the emergency department (ED) while medical, surgical, telemetry, med/surgical, peri-operative, maternal/child locations accounted for the rest. Subjects reported the median number of cardiopulmonary arrests they directly participated in during the past year was 1-5.

Mean provider confidence increased significantly during a single session for each element of resuscitation queried (p range<0.001-0.023) (Table 2). There was a trend for further, although smaller, increased provider confidence for those who attended a second session (Figure 1).

A sensitivity analysis found no difference for those who returned at 6 months for their repeat session rather than at 3 months. Returnees for their second session had mean before-test confidence scores that were similar to their first session after-test scores, possibly indicating that the increased confidence was maintained for 3-6 months. No association between the number of cardiopulmonary arrests subjects directly participated in during either the 3 months or year prior to their first session confidence scores was detected. Participants provided a number of qualitative comments that were positive.

DISCUSSION

Many prior studies of simulation have focused on new learners. Most subjects in this study were experienced, from critical care areas, and had actively participated in several cardiac arrests in the
past year. While confidence may be difficult to measure, the fact that staff volunteered to participate in the un-paid high-fidelity ACLS simulation sessions may indicate its import. Perhaps, the supportive coaching rather than punitive environment played a role. Several authors have described debriefing as a key part of simulation learning, and an area we believe confidence may be gained or lost.2,3  

We focused on confidence rather than knowledge. Benner notes that memorization is frequently used by early learners but doesn’t necessarily translate to clinical judgment in new and difficult clinical situations.4 Confidence may be the bridge between competence and application during actual clinical care. Despite the limits of self-report intervention assessments, it may seem surprising that such a group improved. Despite high baseline confidence scores, levels still increased. This can be useful in recruiting experienced staff for simulation training by demonstrating that they can take something tangible (improved confidence) back to their daily clinical practice.  

As more institutions make simulation training available, many focus on new graduate nurses. While this may be due to costs limitations, our study suggests more experienced staff should not be excluded. Our qualitative comments suggest subjects may have more confidence in applying equipment themselves, being a team leader during the critical time it takes the code team to respond, or even developing the confidence to prompt a young resident, all of which may translate into improved patient care.  

In our study, confidence increased after just one session and was retained for at least 3-6 months between sessions. Other authors have found learning persistence in the 4-6 month time frame.5,6,7,8,9  

**LIMITATIONS**

We note several limitations, primarily those associated with a self-report intervention assessment. The modified confidence scale was explored for content validity with local nurse educators and physicians and thus may not be generalizable. The Satisfaction with Simulation Experience Scale and the Student Satisfaction and Self-Confidence in Learning Scale were just becoming available when this study was conceived.10,11  

| Item | First visit (N=35) | Over first and second visits (N=23) |
|------|------------------|-----------------------------------|
|      | Mean change (95% CI) | p-value | Mean change (95% CI) | p-value |
| 1    | 0.31(0.08, 0.55) | .0095 | 0.43(0.07, 0.80) | .0216 |
| 2    | 0.25(0.03, 0.48) | .0268 | 0.39(0.05, 0.73) | .0254 |
| 3    | 0.51(0.29, 0.74) | <.0001 | 0.83(0.52, 1.14) | <.0001 |
| 4    | 0.41(0.15, 0.67) | .0028 | 0.57(0.25, 0.88) | .0012 |
| 5    | 0.54(0.33, 0.75) | <.0001 | 0.83(0.49, 1.16) | <.0001 |
| 6    | 0.43(0.20, 0.65) | .0005 | 0.57(0.16, 0.97) | .0089 |

* p values refer to the difference in confidence scores between before 1st session and after 2nd session.

**Figure 1:** Confidence results from two sessions: before and after each.
While there are critical thinking scales available, our focus was confidence. This voluntary study was also limited by relatively small convenience sample size. While some may view the high participation of experienced providers as a limitation, we view this as a unique window through which to view the possible benefits of broadly offering high-fidelity simulation education, even to experienced providers.

CONCLUSION

High fidelity simulation is associated with increased health care provider confidence, even with experienced staff. Training should not be limited to new graduates or hires. Further study of the relationship between provider confidence and quality metrics during resuscitation is necessary.

CONFLICTS OF INTEREST: None.

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Hemorrhagic Contents Within Uterine Sac Mimicking Intrauterine Pregnancy on Point-of-Care Ultrasound: A Case Report of a Ruptured Ectopic Pregnancy

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ABSTRACT

We present a case of a female patient who presented to the emergency department (ED) with lower abdominal pain and was found to have a ruptured ectopic pregnancy with hemorrhagic uterine contents mimicking a fetal pole on bedside transabdominal point-of-care ultrasound (POCUS). The case reinforces the importance of accurately interpreting the transabdominal pelvic POCUS for potential mimics of an intrauterine pregnancy. In addition, the case also emphasizes the performance of an abdominal ultrasound for free fluid assessment in the right and left upper quadrants to evaluate for free fluid in patients with concerns for a ruptured ectopic pregnancy.

KEYWORDS: Point-of-care; Ultrasound; Ectopic; Pregnancy; Emergency medicine.

INTRODUCTION

The importance of timely diagnosis of ectopic pregnancy cannot be understated. The incidence of ectopic pregnancy in the general population is approximately 2%.1 The prevalence of ectopic pregnancy in the emergency department (ED) patient population is estimated around 8%.2 Ruptured ectopic pregnancy comprises a significant proportion of these cases. Risk factors for ectopic pregnancy include previous ectopic pregnancy, pelvic inflammatory disease, Chlamydia trachomatis infection, prior intrauterine surgeries, tubal surgery, fertility treatment, endometriosis and smoking.1 Ruptured ectopic pregnancy also comprise a significant proportion of maternal death.1 Fortunately, with appropriate utilization of ultrasound (US) and lab analysis, greater than 85% of ectopic pregnancies can be diagnosed before rupture.1

The diagnosis of an ectopic pregnancy is primarily by US, which can rapidly be evaluated by the Emergency Physician (EP) at the bedside. The presence of an intrauterine gestational sac with yolk sac or fetal pole rules out an ectopic pregnancy unless, in rare cases, a heterotopic pregnancy is present.7 The absence of a uterine gestational sac, or the presence of a pseudosac (small gestational sac, usually <5 mm, with no additional contents), is suspicious
for an ectopic pregnancy, but a proportion of these patients will go on to have a normal IUP. However, if there is also evidence of an adnexal mass then there is a higher likelihood for being an ectopic pregnancy.

When an ectopic pregnancy is a consideration, a transabdominal ultrasound should be followed by a transvaginal study to adequately evaluate the adnexa. When echogenic material, such as clotted blood, is seen within an anechoic uterine sac, the POCUS evaluation can be challenging and must be differentiated from a true yolk sac and fetal pole. Furthermore, in patients with abdominal pain and a possible ectopic pregnancy, a ruptured ectopic pregnancy must be considered. This timely diagnosis is facilitated with the addition of an abdominal ultrasound for free fluid assessment in the right and left upper quadrants, as the presence of free fluid significantly increases the likelihood of a ruptured ectopic pregnancy requiring operative management.

CASE REPORT

A young female patient presented to the ED complaining of abdominal pain for three days. The pain started in both upper quadrants with migration to the right lower quadrant six hours prior to presentation. The pain initially was intermittent, but had become more constant over several hours with associated nausea without vomiting. She had one episode of vaginal bleeding with clots during the day. She denied fevers, chills, diarrhea, melena, dysuria, vaginal discharge, chest pain or shortness of breath. On gynecological history, she reported her Last Menstrual Period (LMP) was over a month prior and denied the possibility of being pregnant despite having one current sexual partner without contraception use. She had one previous spontaneous abortion three years prior and denied previous sexually transmitted infections. She had no other past medical or surgical history. Her social history was positive for daily tobacco and occasional alcohol use.

On physical examination, she was noted to be in moderate distress secondary to pain. Her vital signs included a heart rate of 68 bpm, blood pressure of 117/64 mmHg, respiratory rate of 18 per minute, temperature of 37 degrees Celsius and oxygen saturation of 98% on room air. Her abdomen was soft, but tender to palpation diffusely, especially in the right lower quadrant. She exhibited voluntary guarding without rebound tenderness. Pelvic exam was notable for a closed os, tenderness to palpation over the right adnexa, and no cervical motion tenderness. There was a small amount of blood in the vaginal vault. All other physical exam components were unremarkable.

Initial ED interventions included insertion of an intravenous catheter and obtaining the following tests: a urinalysis, urine pregnancy test, complete blood count and comprehensive chemistry panel. Pain control, antiemetics and a normal saline bolus were also ordered. The point-of-care (POC) urine pregnancy test resulted as positive and a quantitative pregnancy test was added.

The initial POCUS exam included the transabdominal pelvic view (Image 1 and Video 1) which shows an intrauterine fluid-filled sac with hyperechoic linear contents. The ovaries were poorly visualized. A definitive intrauterine pregnancy (IUP) was initially considered, as the linear echogenic material was similar in appearance to a fetal pole. However, there was irregularity in the structure of the intrauterine contents, significant free fluid in the pelvis and no evidence of fetal heart activity. Then, the right upper quadrant abdominal ultrasound was performed (Image 2 and Video 2). This was positive for free fluid around the inferior liver edge within the superior paracolic gutter. These findings increased the suspicion for a ruptured ectopic pregnancy. Ob/Gyn was immediately consulted and requested a transvaginal US by the radiologist per institution protocol for image archiving while they evaluated the patient and prepared for potential operative intervention. The radiologist was able to identify the ectopic pregnancy with fetal heartbeat on transabdominal US due to the
full bladder and thus sent the patient back to the ED without performing the transvaginal scan (Image 3 and Video 3).

The patient was taken emergently to the operating room (OR) for a laparoscopic right salpingectomy and a dilatation and curettage. The operative report described “approximately 200 cc of blood and clot in the pelvis” with a “1-2 cm mass within the right fallopian tube.” Pathology was not completed on the uterine products. The patient had an unremarkable post-operative course and was discharged the following morning, only twelve hours after presentation to the ED.

DISCUSSION

Diagnosis of ectopic pregnancy requires careful interpretation of lab and POCUS examinations. Stein et al performed a meta-analysis that confirmed that EPs are competent in diagnosing ectopic pregnancy by POCUS with a sensitivity of 99.3% and a negative predictive value of 99.9%. With this increasing accuracy of US, reliance on one-time serum beta-hCG levels have proven unreliable as a diagnostic tool due to poor correlation of a single measurement with ectopic pregnancy.8,9 Wang et al evaluated pregnant patients with varying beta-hCG levels and concluded that a beta-hCG discriminatory zone cannot reflect ectopic pregnancy risk.9 Some patients with high beta-hCG levels and no definitive IUP on US can develop a normal IUP on subsequent scans.4,5,9 Thus, administering medication to terminate the pregnancy, or performing surgery, is not advisable based solely on a lab value. Rather, the beta-hCG level should be interpreted in conjunction with the US results and not independent of them.4

Transvaginal US is the single best diagnostic test for ectopic pregnancy.2 Careful interpretation of the pelvic ultrasound is paramount to prevent inadvertent harm to normal early pregnancies.10 When the transvaginal ultrasound shows an adnexal mass and absence of an intrauterine pregnancy, it carries
the highest likelihood ratio of being an ectopic pregnancy.\textsuperscript{4,5} However, the pelvic US can be indeterminate in diagnosing an ectopic pregnancy. One indeterminate finding, as illustrated in our case, includes echogenic material within the gestational sac that is ill-defined and inconsistent with a normal intrauterine pregnancy.\textsuperscript{2,10} A retrospective study by Benson et al showed that 16.6\% of patients with ectopic pregnancies have intrauterine fluid on transvaginal ultrasound, proving that important interpretation of that fluid is imperative in correctly diagnosing an ectopic pregnancy.\textsuperscript{31} According to the authors, type A fluid, or fluid with pointy shaped edges, echoes and/or debris is more common in ectopic pregnancies than type B, or anechoic, intrauterine fluid.\textsuperscript{11} The obvious challenge in our case was the presence of intrauterine echogenic linear contents that, on initial evaluation, seemed to mimic a gestational sac with fetal pole. However, with the absence of cardiac activity and with a high clinical suspicion and careful interpretation of the POCUS findings, the ill-defined contents were differentiated from an actual IUP. The presence of free fluid near the caudal tip of the liver on an abdominal ultrasound for free fluid increased the likelihood of a ruptured ectopic pregnancy requiring surgery.\textsuperscript{7,10,12}

Ultimately, this case report emphasizes the importance of careful interpretation of the pelvic POCUS and the additional performances of an abdominal ultrasound for free fluid assessment in the right and left upper quadrants when evaluating for a ruptured ectopic pregnancy. The physician must differentiate ill-defined echogenic uterine sac contents from an IUP, as these findings can be seen in cases of ectopic pregnancy and, when shaped in a way similar to our images, can mimic a fetal pole.\textsuperscript{10,11} Contents within an intrauterine sac without cardiac activity require transvaginal US to analyze the adnexa and an abdominal ultrasound for free fluid assessment in the right and left upper quadrants to evaluate for free fluid to assess for ectopic pregnancy rupture.\textsuperscript{8,12}

**CONFLICTS OF INTEREST:** None.

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Nowadays, trauma is a serious health problem and can be identified as an injurious event completion from the effect of mechanical, thermal, electrical, chemical or radiation energy. Trauma is still the leading cause of death among people between the ages of 10-40 years and it is also the third most common cause of death for all ages in the industrialized countries. Almost all the patients of traumatic injuries refer to emergency departments and between 15-24 years men are more exposed to trauma than women.

Trauma is accepted to be the fore cause of losing years of life worldwide by the World Health Organization in 2020. Epidemiological studies about traumatic deaths estimate a progressive increase in traumatic injuries by the year 2030. Trauma is also a substantial socio-economic problem and traumatic injuries cause a significant loss in terms of years of productive life and increased health care costs and disabilities.

When death term meets the following three criteria it is conceived avoidable: the individual survives trauma injuries and its outcomes; maintenance provided did not follow curation guidelines; mistakes in patient administration contributed directly or indirectly to an individual’s death.

Preventable deaths can be used to evaluate quality of care protocols and health care systems and these deaths can be essential demonstration of performance and proficiency of administration through trauma patients.

Traumatic deaths can be categorized as non-preventable, potentially preventable and preventable. Absolutely preventable death means that mildly anatomical injuries (pathological categorized organ injury due to the American Association for the Surgery of Trauma categorization with Abbreviated Injury Severity Score (AIS) ≤3) with alterable live threat (tension pneumothorax, serious external bleeding, etc.). Potentially preventable death means that serious anatomical injuries within possibility survivable under excellent conditions and resuscitation or conscious patients with the facility to act at the scene or patients with signs of life at the scene and lack of anatomical non-survivable injuries. Non-preventable death means that anatomical organ or tissue distortion non-survivable although excellent conditions and resuscitation.

A systematic evaluation for the administration of trauma patients international guidelines such as Advanced Trauma Life Support (ATLS), Pre-hospital Trauma Life Support (PHTLS) and Advanced Trauma Care for Nurses (ATCN) have been developed.

In the future, main focus should be prevention programs about traumatic deaths.

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Case Report

A Case of Possible Acute Refeeding Syndrome: A Review of a Rare, But Potentially Life-Threatening Diagnosis

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ABSTRACT

An 18-year-old Hispanic male presented to the Pediatric Emergency Department with acute onset of bilateral lower extremity edema. He had no history of similar symptoms. He had recently lost 70 pounds in the past six-months by restricting himself to an extreme diet and exercise regimen. Two days prior to presentation, he resumed a normal diet. In this illustrative case, we describe a case report of possible refeeding syndrome and discuss the presentation, risk factors, management and potential complications of this diagnosis.

KEYWORDS: Acute refeeding syndrome; Lower extremity edema; Hypophosphatemia.

INTRODUCTION

There is an obesity epidemic in the western world and unfortunately childhood is not immune to its reaches. Nearly 20 percent of children in the United States are overweight or obese. Many quick fixes and crash diets are advertised to aid patients to lose weight. However, without lifestyle and behavior modification, it is nearly impossible to keep off the weight lost during extreme dieting. Additionally, there are risks to extreme dieting which is exemplified in this case.

CASE REPORT

An 18-year-old Hispanic male presented to the Pediatric Emergency Department with acute onset of bilateral lower extremity edema. He had no history of similar symptoms. His recent medical history was significant for an intentional 70-pound weight loss over the past 6 months. This was achieved by restricting his diet to fruits, vegetables, and water only and intermittent vigorous and lengthy exercise. He reported increased urinary frequency and that his urine had been “frothy”. One week prior, he had a syncopal episode while showering. An extensive infectious, neurologic and exposure review of systems was negative. Two days prior to his Emergency Department presentation, the patient resumed a regular diet including carbohydrates and meat. On examination, patient was alert and well appearing. Vitals signs: T: 36.5 °C; HR: 70; RR: 18; BP: 117/74; SpO₂: 99%; WT: 65 kg. There was no lymphadenopathy, no thymomegalgy, no erosions over his knuckles, no parotid gland swelling; his heart had a regular rate and rhythm; his lungs were clear; his abdomen was soft, non-tender, non-distended, without hepatosplenomegaly. On neurologic examination, he had 5/5 muscle strength bilaterally. Lower extremity exam noted 2+ pitting edema noted to bilateral ankles and feet, with symmetrical edema also appreciated to pretibial space (Figure 1), capillary refill was less than 2 seconds, and his extremities were warm and well perfused.
An ECG demonstrated a normal sinus rhythm without prolonged intervals. CXR was normal without cardiomegaly, effusions or vascular cephalization. Laboratory values are listed in the following tabulation:

The patient was admitted to the hospital for electrolyte replacement including 2 grams intravenous magnesium, a total of 50 mmol potassium phosphate intravenously and 1 mg thiamine (vitamin B1) orally. A nutritionist was consulted and his diet was slowly advanced. The patient was discharged two days later with normal electrolytes and improvement, but not complete resolution, of his bilateral lower extremity edema. The patient is now seeing a nutritionist as an outpatient as well as regular check-ups with an internal medicine/pediatrics clinic. However, despite these resources, he was gained nearly 20 pounds in the last two months secondary to unhealthy eating.

**DISCUSSION**

Refeeding Syndrome (RFS) is a complication of acute nutritional rehabilitation (oral, enteral or parenteral) in individuals who are undernourished. It is characterized by metabolic and clinical changes that occur secondary to electrolyte disturbances (principally low serum concentrations of intracellular ions: phosphate, magnesium and potassium) and shifts in fluid balance. Hypophosphatemia is the hallmark of this syndrome. RFS essentially reflects a change from catabolic to anabolic metabolism.

Figure 1: Patient with acute onset of bilateral lower extremity edema.

| Investigation | Finding | Normal Range |
|---------------|---------|--------------|
| Na            | 146     | (135-145)    |
| K             | 3.8     | (3.5-5.1)    |
| Cl            | 104     | (100-110)    |
| CO2           | 26      | (20-30)      |
| BUN           | 9       | (8-22)       |
| CR            | 0.6     | (0.5-1.3)    |
| Glucose       | 78      | (85-99)      |
| Total protein | 6.4     | (6.0-8.0)    |
| AST           | 27      | (10-40)      |
| ALT           | 26      | (10-50)      |
| Total bilirubin| 0.3  | (0.1-1.0)    |
| AlkPhos       | 104     | (40-130)     |
| Pro BNP       | 141     | (0-125)      |

| HIV Ab | Nonreactive | Reactive/Nonreactive |
|--------|-------------|----------------------|
| Mg     | 1.8         | (1.7-2.3)            |
| Ca     | 9           | (8.5-10.3)           |
| Phos   | 1.5         | (2.5-4.6)            |
| ALB    | 4.4         | (3.5-5.5)            |
| pre-alb| 18.6        | (19.38)              |
| VIt B1 | 74          | (78-185)             |
| Vitamin D 25 OH | 31 | (30-96) |
| PTH    | 21          | (15-65)              |
| WBC    | 7.3         | (3.7-10.3)           |
| Hbg    | 12          | (13.8-16.9)          |
| Hct    | 35.9        | (41.0-50.0)          |
| Pt     | 120         | (150-350)            |
| UA specific gravity | 1.008 | (1.005-1.030) |
| UA pH  | 6.5         | (5.5-8.0)            |
| UA     | Negative    | for protein, glucose, ketones, bilirubin, blood, leukocytes, nitrates |

Table 1: Differential diagnosis for RFS.

Acute refeeding syndrome was clinically suspected in this patient. However, as it is a clinical diagnosis RFS was not able to be confirmed with certainty. Additional etiologies...
of electrolyte abnormalities were pursued with vitamin D levels and parathyroid hormone levels. Normal liver enzymes, renal function and lack of cardiac abnormalities make alternative etiologies of peripheral edema less likely. The diagnosis of Kwashiorkor was also considered as an alternative etiology of patient’s edema but patient and family were emphatic that the edema began immediately after a regular diet was resumed and did not occur previously as would be expected if the etiology was protein-deficiency. Additionally, the albumin level was normal making kwashiorkor unlikely.

**REVIEW OF ACUTE REFEEDING SYNDROME**

**Pathophysiology**

To understand the mechanism behind RFS, it is important to understand the physiology behind starvation/under nutrition. In starvation, the body shifts from an anabolic metabolism to a state of catabolism in an effort to compensate for lack of available energy. This change results in a shift from carbohydrate metabolism to protein and fat catabolism. The metabolism of proteins results in a breakdown of lean body mass, which directly affects major organs. In the heart, atrophy of the myocardium causes poor contractility and decreased cardiac output. Atrophy of the liver causes decreased protein production, which exacerbates the metabolic state. Additionally, during starvation there is intracellular loss of electrolytes (potassium magnesium and phosphate). Insulin secretion decreases, the basal metabolic rate slows and the body becomes bradycardic, hypothermic and hypotensive all in an effort to conserve protein and organ function.3

When nutritional rehabilitation is started, the body immediately shifts to an anabolic state, metabolizing carbohydrates instead of proteins and fat. This new glucose load causes the body to increase insulin secretion and cells begin to uptake glucose, potassium, magnesium and phosphate.3 This is the cause of the electrolyte disturbances commonly seen in refeeding syndrome (hypokalemia, hypomagnesemia and hypophosphatemia). Additionally, insulin has a natriuretic effect on the kidneys, resulting in sodium retention and an increase in extracellular volume.3

**Risk Factors**

There is no standardized definition for RFS, however, there are proposed clinical criteria to determine those patients at risk.2 Table 2 outlines a risk stratification tool for adults.4

A study by Dun et al and several additional case reports have shown that in the Pediatric population, one of the most frequent risk factors for RFS is a calculated body weight less than 80% of the ideal body weight.5 Additional risk factors for RFS in pediatric patients are shown in Table 3.3

**Clinical Presentation and Medical Complications**

The features of RFS result from various electrolyte, hormonal and fluid disturbances. As such, patients may present with symptoms of hypophosphatemia, hypokalemia, hypomagnesemia, hyperglycemia, fluid overload or thiamine deficiency.3 These findings are outlined below:

| Patients are at risk for RFS if they have: |
|------------------------------------------|
| One of the following:  |
| Body mass index (BMI) <16 kg/m²  |
| Unintentional body weight loss >15% in the preceding 3 to 6 months  |
| Very little or no nutritional intake for >10 days  |
| Low concentrations of plasma potassium, phosphate or magnesium prior to feed  |
| Or two of the following:  |
| BMI <18.5 kg/m²  |
| Unintentional body weight loss >10% in the preceding 3 to 6 months  |
| Very little or no nutritional intake for >5 days  |
| History of alcohol or drug abuse  |

**Table 2: Risk factors for RFS.**

| Anorexia Nervosa |
|-------------------------------|
| Patients underfed or not fed for at least 10-14 days (including those on prolonged intravenous fluids without adequate calories or protein) |
| Acute weight loss >10% in the past 1-2 months (including obese patient with extensive weight loss in a short period) |

| Kwashiorkor |
|-----------------|
| Chronic medical conditions causing malnutrition (uncontrolled diabetes mellitus, cancer, congenital heart disease, chronic liver disease) |
| Mal absorptive syndromes (inflammatory bowel disease, cystic fibrosis, chronic pancreatitis and short bowel syndrome) |
| Cerebral palsy and other conditions causing dysphagia |
| Children of neglect |

| Marasmus |
|----------------|
| Postoperative patients, including after bariatric surgery |

**Table 3: Pediatric Risk Factors for RFS.**
Hypophosphatemia: The hallmark feature of RFS is hypophosphatemia. Starvation results in loss of total body phosphate and refeeding causes cells to uptake phosphate for anabolic processes and the synthesis of phosphorylated intermediates of glycolysis (i.e.: ATP and 2,3-diphosphoglycerate). These processes can result in severe extracellular (serum) hypophosphatemia. The hypophosphatemia seen in RFS generally presents within 24-72 hours of reintroduction of nutrition, with a nadir during the first week.

Phosphate has ubiquitous actions in humans. It is essential for intracellular buffering and is also a major structural component of phospholipids, nucleoproteins and nucleic acids. It is needed for glycolysis and oxidative phosphorylation and plays a role in nervous system conduction, chemotaxis, phagocytosis and platelet aggregation. Therefore, signs and symptoms of hypophosphatemia may include:

- Cardiac: Hypotension, decreased stroke volume.
- Respiratory: Poor respiratory function from decreased diaphragm contractility Neurologic: paresthesias, weakness, cramps, seizures.
- Hematologic: Leukocyte dysfunction, hemolysis, thrombocytopenia.
- Psychologic: Confusion, altered mental status, coma.

Hypokalemia: By the same mechanisms described in hypophosphatemia, refeeding can also result in hypokalemia. Potassium is crucial to cell membrane function and acid-base balance. Signs and symptoms of hypokalemia may include:

- Cardiac: Arrhythmias.
- Respiratory: Respiratory failure.
- Neurologic: Weakness, paralysis.
- Gastrointestinal: Nausea, vomiting, constipation.
- Muscular: Rhabdomyolysis.

Hypomagnesemia: Another electrolyte abnormality that can be seen in RFS is hypomagnesemia. Magnesium is an essential cofactor for various enzymes (in ATP production and oxidative phosphorylation) and is important for cell membrane function and cell structure. It is also involved in the structural integrity for DNA, RNA and ribosomes. Additionally, low magnesium levels may induce hypokalemia by impairing Na+/K+ ATPase activity. It is also needed for parathyroid function, so hypomagnesemia can cause hypocalcemia. Signs and symptoms of hypomagnesemia may include:

- Cardiac: Arrhythmias.
- Neurologic: Weakness, tremor, tetany, seizures, altered mental status.
- Gastrointestinal: Nausea, vomiting, diarrhea.
- Other: Refractory hypokalemia and hypocalcemia.

Thiamine and Vitamin Deficiencies: Thiamine (vitamin B1) is an essential nutrient for humans, since it cannot be synthesized in the human body. It is an important cofactor in many metabolic pathways and its deficiency can result in beri-beri and metabolic acidosis. The half-life of thiamine is 9.5-18.5 days, so thiamine deficiency can manifest in less than 28 days. Clinical manifestations of thiamine deficiency include Korsakov’s psychosis and Wernicke’s encephalopathy syndrome which may present with ataxia, coma, confusion or seizures. Signs and symptoms of thiamine deficiency may include:

- Neurologic: Encephalopathy.
- Other: Lactic acidosis, Death.
- Other vitamin deficiencies, such as vitamin B12 and vitamin B6 as well as folate can also been seen in refeeding syndrome, though the mechanism is unclear.

Alterations in Fluid Balance: Fluid overload can be seen in RFS secondary to sodium retention. In refeeding with carbohydrates, there is an insulin surge that decreases renal excretion of water and sodium and results in expansion of the extracellular fluid compartment and weight gain. Additionally, the insulin surge stimulates an intracellular influx of phosphate, potassium and magnesium. In order to maintain electro neutrality of the extracellular space, sodium and subsequently, water is retained. Signs and symptoms of fluid overload may include:

- Peripheral edema.
- Pulmonary edema
- Cardiac compromise

Hyperglycemia: When feeding is reinitiated after starvation, increased glucose load inhibits gluconeogenesis and reduces the amount of amino acid use. This results in a decreased ability to metabolize glucose and subsequent hyperglycemia. Additionally, during refeeding the body undergoes a stress response that increases glucocorticoids and further exacerbates hyperglycemia. This state of elevated glucose can cause hyperosmolar nonketotic coma, ketoacidosis, metabolic acidosis, osmotic diuresis and dehydration. Lastly, with the increased surge of insulin there is increased lipogenesis which, if paired with excess fat intake, can cause fatty liver, hypertriglyceridemia, thrombocytopenia, increased carbon dioxide production, hypercapnia and respiratory failure in some patients. To summarize, some of the symptoms associated with hyperglycemia may include:

- Cardiac: hypotension.
- Respiratory: hypercapneic failure.
- Other: ketoacidosis, coma, dehydration, impaired immune function.

DIAGNOSIS

Refeeding syndrome is a clinical constellation of symptoms, as described above, that results from electrolyte imbalances and fluid shifts. It is diagnosed clinically and can be supported by measuring patient electrolyte levels including phosphate, magnesium, and thiamine.
MANAGEMENT

In order to prevent RFS, it is essential to identify those patients who are at an increased risk and to strictly monitor nutritional intake, electrolyte and fluid replacement. The following sections will outline the prevention and management of various components in RFS.

Nutritional Support

Current guidelines regarding the initiation of nutritional support in patients at risk for RFS recommend slow, low energy feeds. The National Institute for Clinical Excellence (NICE) suggests a gradual increase in energy intake with a goal weekly body weight gain of 0.5 to 1 kg. Other proposed recommendations suggest starting feeds at 25-75% of resting energy expenditure and in both adult and pediatric patients, to increase the caloric intake 10-25% per day over 4-5 days until their calorie goals are met. Additionally, there are suggestions that the actual composition of nutrition in refeeding may be more important than the energy content alone. For example, there have been observations that RFS is more likely to occur when carbohydrate is the main source of energy, while feeds that are low in amino acids are less likely to develop hypophosphatemia. Therefore, the recommendations include:

• Carbohydrates: Maximum of 40% total energy intake.
• Protein: 1.2-1.5 g/kg.
• Fat: 3.8 g of lipid/kg (maximum daily lipid-elimination capacity).2

Fluid and Electrolyte Management

Fluid balance and daily weights should be closely monitored to avoid fluid overload and cardiac compromise. Sodium should be limited to 20 mEq/d and total fluid intake to 1000 mL/d or less in order to reduce refeeding edema. While some sources suggest that electrolyte deficiencies be corrected prior to the initiation of feeding, others state that the abnormalities can be corrected while refeeding, so nutritional support is not delayed.

Hypophosphatemia

There is no universal agreement on the best way to treat severe hypophosphatemia in RFS and some proposed treatment regimens are not effective in correcting it. In some cases, oral phosphate replacements have been used, but they can cause diarrhea and nausea. As such, other guidelines suggest the use of intravenous (IV) phosphate replacement as its absorption is more reliable. One guideline proposed by the Lucile Packard Children’s Hospital at Stanford suggests IV replacement doses as follow:

• Children: initial dose of 0.08-0.24 mmol/kg with a maximum single dose of 15 mmol and a maximum daily dose of 1.5 mmol/kg.
• Adults: initial dose of 0.08 mmol/kg if mild hypophosphatemia (2.3-2.7 mg/dL), a dose of 0.16 mmol/g if severe hypophosphatemia (<1.5 mg/dL) with a maximum dose of 0.24 mmol/kg per dose.

These should be given over 6-12 hours and serum phosphate level should be obtained 2-4 hours after the completion of the infusion.

Hypokalemia

Like many of the other oral electrolyte replacements, oral potassium can also cause GI upset, so IV potassium replacement is often suggested. Additionally, prior to the initiation of potassium replacement, urine output should be greater than 0.5 mL/kg/hr and the patient should be on a cardiac monitor given the risk of hyperkalemia and potential arrhythmias. Guidelines for potassium replacement include:

• Children and Adults: 0.3-0.5 mEq/kg per dose with a maximum dose of 30 mEq.

Replacement should be administered over at least 1 hour and serum potassium should be obtained within 2 hours of completion of the infusion.

Hypomagnesemia

Hypomagnesemia can be corrected orally, but can be poorly absorbed and cause diarrhea, so IV forms are often used. Guidelines for IV magnesium sulfate replacement suggest:

• Children: 25-50 mg/kg per dose with a maximum single dose of 2000 mg.
• Adults: 1 g every 6 hours for four doses for mild-moderate hypomagnesemia (1-1.8 mg/dL) and 8-12 g/d in divided doses for severe hypomagnesemia (<1 mg/dL).

Replacement should be given over 4 hours.

Thiamine and Vitamin Supplementation

Daily multivitamin supplementation should be started with refeeding and continued for at least 10 days. Specifically for thiamine deficiency or Beriberi, guidelines suggest:

• Children: 10-25 mg/d IV or intramuscular (IM) if ill or 10-50 mg per dose orally every day for 2 weeks and then 5-10 mg/d for 1 month.
• Adults: 5-30 mg per dose 3 times a day either IV or IM and then 5-30 mg/d orally for one month.

Clinical Monitoring for Complications

Patients should be closely monitored for the development of complications of RFS. Electrolyte abnormalities typically occur
in the first days of starting nutritional supplementation, cardiac complications within the first week and altered mental status thereafter. During re-feeding, patients may require continuous cardio respiratory monitoring and neuromuscular and mental status checks. Daily body weights and strict monitoring of intake and output are essential to preventing fluid overload. Daily measurement of electrolytes and weekly prealbumin and albumin levels have also been suggested. If complications of RFS emerge during feeding, nutritional supplementation should be stopped and corrective measures should be taken (ie: respiratory support, diuretics, vasopressors) prior to the re-initiation of feeds.

CONCLUSION

Refeeding syndrome is rare but most commonly seen within the first two weeks of nutritional replenishment and can have numerous non-specific symptoms, affecting many organ systems. Electrolyte disturbances are most common, especially hypophosphatemia, hypokalemia, and hypomagnesemia. In the Emergency Department, it is important to recognize this syndrome and its potentially serious complications including multi-system organ involvement/failure.

CONFLICTS OF INTEREST

Drs. Harada, Greenberg and Rose do not have any conflicts of interest to report.

CONSENT

Informed consent for photography and case write-up was obtained from the patient and his family.

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