Of Lobsters, Electronic Medical Records, and Neonatal Total Parenteral Nutrition

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ABSTRACT

At the Mayo Health System in LaCrosse, Wisconsin, there are >1000 infant total parenteral nutrition (TPN) orders placed per year. It is the most complicated order that the pharmacy fills, so a recent peer-review article in *Pediatrics* moved a group of us to action at our center to buy or develop a TPN calculator. We did this because no stand-alone commercial calculators were available to us, and expensive electronic medical records typically do not include TPN calculators for neonatal patients. The new software includes decision support, and the orders are consistently legible. The physician performs fewer calculations, and there are no mathematical errors. This article examines the broader significance of providers having to write their own TPN software.

At the Mayo Health System in LaCrosse, Wisconsin, there are >1000 infant total parenteral nutrition (TPN) orders placed per year. It is the most complicated order that the pharmacy fills, so a recent peer-review article in *Pediatrics* moved a group of us to action at our center to buy or develop a TPN calculator. This article by Lehmann et al of Johns Hopkins, “Preventing Provider Errors: Online Total Parenteral Nutrition Calculator,” relates that the John Hopkins Medical Center was able to take paper ordering of neonatal TPN and make an electronic ordering program within 3 weeks by using in-house talent. More importantly, they showed what I suspected: value to patients. They were able to reduce errors from 10.8 per 100 TPN paper orders to 1.2 errors (89% reduction) by using this electronic format. Two thoughts immediately came to mind: if they can do it, why can’t we? I did my neonatology fellowship at Cornell University, and we always wrote neonatal TPN orders electronically; thus, I wondered if I could just get the program from them. Nevertheless, I finished my fellowship at Cornell–New York Hospital Medical Center 16 years ago, and I remember from my last visit to them that they had not only purchased an expensive electronic medical record (EMR) system but had merged with Columbia University Presbyterian Medical Center, so I was not sure if friends at Cornell could just send me a neonatal TPN program. I began to wonder how the Cornell software would integrate into the expensive EMR system that they had purchased a few years ago. Maybe the new EMR system at Cornell included a TPN calculator. Maybe most EMRs do not include TPN calculators. I made some phone calls, and I learned from the director of a large academic NICU (he prefers not to be named) what occurs at his center: “NICU staff and residents still submit TPN orders on paper despite an expensive EMR, and lunchtime always means numerous phone calls to prevent errors because of math errors or handwriting that cannot be deciphered by a nurse or pharmacist.”

The second thought I had was that reimbursement rules largely don’t recognize information technology–related capital expenditures, but if I assembled a team to write a neonatal TPN program for our patients, we could theoretically do it on salaried, already paid time; thus, we could get more value for the “health care” dollar of our patients. In fact, not only is medical software expensive, but we cannot always buy what medical software...
we need, nor can we fix problems or implement advances without spending more money on updates or new vendors. The John Hopkins work in *Pediatrics* relates how, if we write it ourselves, we can “find it, fix it, and forget it” and get good value for very little financial cost to our patients. This targeted surgical approach (cutting out the problem and replacing the defective process) was applied by Lehmann et al, in conjunction with the significant domain knowledge of his team in the area of TPN, allowed the design of an application that did reduce errors. If we wrote such a program, we would have to follow Title 21 Code of the federal regulations, which requires software systems to ensure accuracy, reliability, and consistency. We thought that if we found a problem, we would fix it and be cautious that the fix would not generate an error risk before we “forgot it.”

It became apparent that I could not buy a neonatal TPN program for our NICU. I called Alfred N. Krauss, MD, at Cornell and learned that a second-year pediatric resident wrote a homegrown TPN program by using Microsoft Excel (Seattle, WA). I was amazed that a pediatric resident had to write a calculator after Cornell had purchased an EMR system for millions of dollars (Alfred N. Krauss, MD, written communication, January 4, 2005). I was not even sure if the Mayo Health System would just let me begin using Cornell’s neonatal TPN calculator, but Dr Krauss told me that he could not just give the program to me.

Thus, with the agreement of our medical director and our organizational spokesperson for system reliability and patient safety (Stephen P. Shultz, MD), we followed the John Hopkins example and made our TPN calculator by using Microsoft Excel. We (myself, Jose Yuvienco, MD, and Karen Olson, RN [of our neonatology department], Scott W. Mihalovic, PharmD, RPh, and John K. Johnson, RPh [of our pharmacy], and Gina L. Howlett, BSN, RN, and Jerrilyn R. Hendrickson, AB [of our information-services department]) did this because no standalone commercial calculators were available to us, and expensive EMR systems typically do not include TPN calculators (especially for infants). I found this hard to understand given the results of a Harvard study published in 2001, which found that 79% of potential adverse drug events (ADEs) are preventable, and the potential ADE rate is highest among neonatology inpatients when compared with an older population. The US Food and Drug Administration, World Health Organization, and International Committee on Harmonisation define an adverse drug reaction as a “response to a drug which is noxious and unintended and occurs at doses used in man for prophylaxis, diagnosis, therapy or modification of physiologic functions.” In fact, although some studies (Boston, MA) can show only a 17% decrease of serious preventable ADEs, other studies have shown an 81% decrease of serious preventable ADEs because of a computerized provider order entry (CPOE) system. In fact, I wonder if that is not why Lehmann et al wrote their own TPN-calculator program?

We used ranges based on recommendations for TPN published by the American Academy of Pediatrics (AAP), nutritional needs of the preterm infant, and some recent nutritional updates for premature infants. I could not help wondering if a Web-based calculator from the AAP would not be a good addition to their textbook? After all, I thought, why do TPN orders have to be so dependent on which medical center a given infant is born? Would not how much protein, multivitamins, and trace elements in the TPN be based largely on the birth weight and gestation? The software could give decision support (eg, how much cysteine for a given number of grams of protein) or an alert to decrease trace elements if the infant has liver disease by using the same sound medical evidence and consensus already contained in the Pediatric Nutrition Handbook. The AAP experts would have the best understanding of how much decision support the average doctor might need to safely and efficiently compose TPN for most neonatal patients.

Do I think there will be demand for such a calculator? Yes. In a recent survey describing neonatal nutrition-design techniques for very low birth weight infants at 8 neonatal centers in North Carolina, the authors documented the low frequency with which NICUs use electronic ordering systems to design parenteral nutrition. It has been estimated that 750 000 neonatal TPN orders are prescribed each year in the United States. How and what percent of neonatal units use an electronic TPN calculator could be ascertained by an AAP or even a Vermont-Oxford survey, but why should the state of North Carolina be atypical? I wrote to the editor of the AAP’s Pediatric Nutrition Handbook, who told me that the expectation is that most doctors are making these programs (Ronald E. Kleinman, MD, written communication, June 22, 2005).

The new TPN software that we created is working wonderfully, and multiple peer-review articles in the medical literature discuss the importance of both quantitative and qualitative assessments of new ordering systems. Lehmann et al also performed a quantitative study, so I will give the qualitative perspective of an electronic TPN calculator (Fig 1). The orders are legible and have reduced “the risk for error.” When my partner and I fill out TPN orders for an infant, we enter data into 24 fields, and the computer calculates the other 35 field values, with no mathematical errors. This saves us laborious, tedious calculations that we ordinarily would have to do for several infants per day. On any given day, not only can we write a TPN order faster and with more accuracy and safety, but we can also review it and adjust components if necessary (eg, a few milliliters more of fluid or a little more dextrose) without starting all over again. The computer helps us to modify the TPN solution as enteral feeds increase and calculates TPN changes as...
FIGURE 1
Franciscan Skemp-Mayo physician orders for patients <1 year of age.
we adjust arterial-line fluid rates. The computer saves
the order; the next day, any needed changes are made in
the saved copy, so the order takes even less time. While
creating our homegrown software, we made sure that
there were no fragmented displays of the orders (one
screen shows all the TPN components).13 The new soft-
ware delivered exactly what I would expect from a well-
designed CPOE system, which provides support to us in
2 principal ways:

1. It standardizes repetitious (high-volume) tasks: errors
   in information transfer processes can be reduced
   through the use of guided and automated data entry
   and validation and standardized terminologies to pro-
   vide legible and verified orders and communications.
   Commercial CPOE systems use this strategy (if noth-
   ing else, all orders will be legible).

2. It simplifies complex (error-prone) tasks: errors
   caused by cognitive overload can be reduced through
calculation, reminders, and rule-based decision sup-
port at the bedside. Decision support provides data to
the provider to optimize the selection and specifica-
tion of medication for ordering.

We presented our new program at the Mayo Clinic
Formulary and Pharmacy Retreat as an example of pa-

tient benefit at low cost and offered to let other Mayo
Clinic practice sites use or create their own software
from already existing paper orders. The program was
well received by the group, and they particularly liked
the edits and reminders that we built-in for patient

safety. We enter the TPN orders into a computer, and
subsequent generation of alerts and reminders means
that the pharmacist does need to call us. The nurses love
the legibility of the computer TPN orders. We not only
observed for any errors that we want our software to
prevent, but we looked and surveyed staff for any errors
that might be caused by our new software; we did not
find any errors caused our new TPN software. Alarms
were not ignored, there were no computer crashes (and
we still had the ability to write the same orders on
paper), and no orders were entered into the wrong
medical record. In our NICU, one doctor per day orders
all the TPN. We have a dedicated computer for the 2
neonatologists, so there is always a clear log-on/log-off
status for each physician. Our development time was a
few weeks, and we did this without sacrificing our other
patient, academic, and administrative duties.

After our new TPN calculator was made and being
used, I wrote to Lehmann, and he sent his TPN program
to me free of charge within an hour of my e-mail (Chris-
toph U. Lehmann, MD, written communication, July 20,
2005). Why didn’t I just do that in the beginning?

Is there a broader significance to all this? We think
reported that our government would like the health care
industry to move toward electronic ordering of medica-
tions and an EMR.14 The thinking is that as 40% of the
health industry becomes electronic, the societal dividend
will be a 10% reduction in medical errors. In fact, “if
steps are not taken soon to make it happen, the govern-
ment will probably impose a solution.”14

In the June 2005 issue of Hospitals & Health Networks,
the Journal of the American Hospital Association discus-
ses the thoughts of David Brailer, MD, the federal govern-
ment’s national health information technology coordi-
nator, at the Healthcare Executive Forum: “Brailer was
damant that government should not decide the techni-
cal infrastructure that will allow interoperability, or the
ability for patient information to seamlessly flow from
one provider or institution to another within 10 years.
Brailer suggests the government should encourage the
industry to do it, and ensure that the ultimate design is
fair. This has got to live in the private sector, but I think
regulation is always an option… that might be where we
end up.” *15

I do not think that a government mandate is neces-
sary, and I think discussion on the Maine lobster indus-
try is a good example for pediatrics and medicine. In
1976, the US Congress passed legislation called the Fish-
ery’s Conservation and Management Act. The federal
government began to have control over the fishery with
a well-intended law to protect US waters from foreign
fishing fleets. It also empowered the National Marine
Fishery Service to analyze the lobster fishery in the Gulf
of Maine. The federal government thought that too
many lobsters were being caught before making eggs
and thus predicted that federal regulators would need to
play a very active role or the lobster population would
dwindle and the industry would collapse. Over the
years, however, the lobster populations in the Gulf of
Maine actually grew. The federal government had not
noticed a conversation practice that Maine lobstermen
had long prided themselves as being homegrown: if they
thought a lobster was a breeder, they put it back into the
water. The government regulators missed this conserva-
tion practice.16

Is there any chance that physicians and the health
care industry are proving to be like Maine lobster fish-
erman? I believe so, and with the latest estimate for the
cost of electronically connecting America’s health care
system running approximately $300 billion US dollars,
the return on investment will depend on physicians to
actively assess and create safer CPOE products.17 Con-
sider Wisconsin’s Peridata as another good example.
Peridata is the result of a unique public-private partner-
ship in Wisconsin called PC-log.18 Peridata is affordable
(approximately $5000 to start up) and will allow almost
all of the Wisconsin hospitals with midwifery and ob-

stetrics to compare and benchmark patient outcomes
within the state of Wisconsin. Peridata allows electronic
reporting of birth certificates. Peridata creators are work-
ing on electronic reporting to Vermont-Oxford, and I am recommending to my Wisconsin colleagues that Peridata follow the example set by Lehmann et al and create a reliable, Web-based neonatal TPN calculator. Thus, I believe a federal mandate for health care to be computerized would be premature.

In summary, Vermont-Oxford, Peridata, and the excellent work by Lehmann et al and those at Cornell University are good examples of why I think it is important that pediatricians be actively involved in the creation of new software and the purchase of existing CPOE systems. Otherwise, we may wake up to find a federal regulator in the neonatal TPN.

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