Intervention to Reduce Inappropriate Ionized Calcium Ordering Practices: A Quality-Improvement Project

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ABSTRACT

Context: The importance of an abnormal ionized calcium (iCa) measurement in noncritically ill patients is unclear. Furthermore, iCa monitoring is more expensive than measurement of total calcium and consumes more laboratory resources. We hypothesize that most iCa tests are ordered for routine monitoring in asymptomatic patients, and results do not influence clinical management.

Objective: To characterize and to intervene on iCa test-ordering practices among our institution's hospital-based internal medicine clinicians.

Design: A quality-improvement project, with retrospective review of clinical records. We retrospectively identified the first 100 consecutive patients admitted to our hospital internal medicine (HIM) services during January 2012 with an iCa test ordered during their hospitalization. We reviewed clinical records to determine the appropriateness of iCa test ordering and of the ordering department. An educational intervention regarding the appropriateness of iCa testing was undertaken targeting HIM clinicians.

Main Outcome Measures: The effect of the intervention was assessed by identifying a sample of the first 100 consecutive patients admitted to HIM services during November 2012 and by comparing the proportion of iCa tests ordered by HIM clinicians before and after the intervention.

Results: HIM services were responsible for 38% of iCa measurements before the educational intervention, with the remainder originating primarily from the Emergency Department (29%) and intensive care units (28%). After the intervention, the internal medicine services were responsible for 13% of iCa measurements, which represented a 66% reduction ($p = 0.0007$).

Conclusion: A simple intervention based on clinician education can reduce the frequency of routine iCa monitoring in stable hospitalized patients.

INTRODUCTION

Calcium homeostasis is critical for maintaining the physiologic functioning of most major organ systems in health and in disease. Although population studies have defined normal ranges of serum total calcium and serum ionized calcium (iCa) in healthy subjects, little is known about "optimal" total calcium and iCa in acutely and/or critically ill patients. In fact, neither observational nor experimental studies are available to guide management in this setting. It is possible that parenteral supplementation might be detrimental in the long term. Indeed, this controversial topic was highlighted in a prior Cochrane systematic review examining the effects of calcium supplementation in intensive care unit (ICU) patients.[1] Additional concerns related to iCa monitoring are the increased cost and laboratory resource utilization compared with total calcium monitoring.[2,3]

In the absence of evidence to support routine iCa monitoring, we sought to characterize clinicians' ordering practices among several hospital internal medicine (HIM) services in a large academic medical center. We hypothesized that most iCa tests are ordered for routine monitoring in asymptomatic patients, and the results do not influence clinical decision making. As part of an ongoing quality-improvement project, this study's aims were twofold: 1) to assess the frequency of iCa measurements on our HIM services and 2) to assess the efficacy of an intervention based on clinician education to reduce the frequency of routine iCa monitoring.

METHODS

We retrospectively queried the laboratory database to identify the first 100 consecutive patients admitted to 6 HIM services in the Mayo Clinic, Rochester, MN, during January 2012, for whom an iCa test was ordered at any time during their inpatient episode. These 6 HIM services are staffed by physician assistants, nurse practitioners, and hospitalists. Using the electronic medical record (EMR), we identified the individual clinicians and departments responsible for ordering the iCa test. For example, a patient admitted to an HIM service may have an iCa test ordered as part of an Emergency Department (ED) or ICU evaluation. We also considered the possibility that the iCa test was ordered before a handoff of care (eg, routine morning laboratory tests ordered before a patient transfers from the ICU to an HIM service).

Two authors (DBN, KCS) reviewed all cases involving an iCa result originating from an HIM service. We reviewed

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the EMR looking for explicit comments by the HIM clinicians regarding the iCa indication. If no such comment was recorded in the HIM admission or progress notes, the EMR was then reviewed for active and/or historic medical conditions that might warrant iCa assessment (see Sidebar: Clinical Scenarios Generally Regarded to Warrant Ionized Calcium Monitoring) on the basis of available data and expert clinical opinion.[4,5] In situations where the indication for ordering an iCa test was in question, the two authors jointly reviewed the record to determine the indication. If a medical indication for iCa monitoring was not found, we considered this to be "inappropriate" ordering. We then quantitated the total number of iCa measurements and categorized them according to ordering department. We documented the ordering patterns in the ED and ICUs, but no intervention was performed in these departments and we did not interact with those groups.

A root-cause analysis indicated that lack of clinician awareness regarding the indications of iCa testing was the most significant factor likely contributing to the problem. Therefore, an educational intervention was undertaken consisting of a ten-minute presentation in February 2012 at a monthly HIM division meeting outlining the purpose of the quality-improvement project, the patient charge and additional laboratory resource utilization of iCa vs total calcium measurement, and the clinical scenarios generally regarded to warrant iCa measurement (see Sidebar: Clinical Scenarios Generally Regarded to Warrant Ionized Calcium Monitoring). The HIM division meeting is attended by HIM consultants, HIM fellows, nurse practitioners, and physician assistants. In addition, we identified the individual clinicians with the most frequent iCa test orders and provided additional discussion and one-on-one feedback.

To assess the effect of the intervention, we conducted another sampling of the first 100 consecutive patients admitted to HIM services during November 2012. We again sought to identify the ordering department and individual clinician responsible for the iCa test order. The primary outcome was the percentage difference of iCa test orders originated from the HIM services under investigation before and after the educational intervention. A χ^2 test was used to assess the change in proportion of iCa tests ordered by HIM clinicians before and after the intervention. As in the preintervention sample, the appropriateness of iCa testing was examined by review of the medical record using the indications listed in the Sidebar: Clinical Scenarios Generally Regarded to Warrant Ionized Calcium Monitoring.

Clinical Scenarios Generally Regarded to Warrant Ionized Calcium Monitoring

- Hypoparathyroidism following thyroidectomy
- Chelation after plasmapheresis or transfusion with citrated blood
- Severe pancreatitis
- Severe sepsis
- Severe metabolic alkalosis (pH > 7.5) and acidosis (pH < 7.3)
- Renal replacement therapy with a citrate dialysis bath
- Cardiac dysfunction associated with new or worsening left ventricular systolic function, prolonged QTc, and/or ventricular arrhythmias
- Administration of drugs associated with hypocalcemia: mithramycin (also known as plicamycin), bisphosphonates, calcitonin, and oral or parenteral phosphate preparations
- Administration of chemotherapeutic agents associated with hypocalcemia: cisplatinum, combined use of 5-fluorouracil, and leucovorin

Table 1. Ionized calcium tests ordered before and after the intervention

Ordering department	January 2012 (n = 100)	November 2012 (n = 100)
Hospital internal medicine	38	13
Intensive care units	28	45
Emergency Department	29	36
Other	5	6

RESULTS

The results of the Mayo Clinic laboratory database search are shown in Table 1. The included HIM services were responsible for 38 (38%) of the total 100 iCa tests ordered, with the remainder originating from the ED (29%), ICU (28%), and miscellaneous departments (5%). Following the educational intervention, the HIM services were responsible for 13% of iCa test orders, which amounted to a 66% reduction ($p = 0.0007$). Among HIM clinicians, consultants were responsible for 78% (n = 30) and 54% (n = 7), and midlevel clinicians were responsible for 22% (n = 8) and 46% (n = 6) of iCa test orders before and after the intervention, respectively.

In none of the HIM test-ordering instances was there any documentation for the rationale of iCa testing. The review of the EMR showed that iCa testing was appropriate only in 1 instance of 38 (3%) before the intervention and in 1 instance of 13 (8%) after the intervention.

DISCUSSION

Our data indicate that simple educational interventions along with targeted clinician feedback regarding effective test utilization can alter clinicians' ordering patterns to reduce inappropriate and costly laboratory testing in a sustained manner. These interventions are inexpensive and provide an educational opportunity for improved patient care.

We found a surprisingly high number of iCa measurements among our HIM services despite a limited number of clinical scenarios that warrant direct measurement of iCa as well as an absence of data to support parenteral replacement in patients without signs or symptoms attributable to hypocalcemia. Ideally, the results of diagnostic testing should guide further diagnostic testing and therapeutic interventions with the potential to improve patient outcomes. However, there is a paucity of diagnostic tests with such characteristics in clinical medicine.[6] The rationale for iCa testing was not documented in the admission record or progress notes for any order originating

from an HIM service. We would therefore assume that the indication for iCa measurement originating from the included HIM services was, overwhelmingly, for routine monitoring. We also hypothesize that most iCa test orders originating from the ED and ICUs were also for routine monitoring; however, this would take further research to clarify.

Tantamount to a paucity of outcomes data on parenteral calcium supplementation in critical or noncritical illness, iCa measurement is more costly than total calcium measurement. However, besides the cost difference, one also must consider the additional complexities of iCa measurement, including handling and transport, the laboratory equipment calibrated and devoted to iCa measurement, and the additional personnel required to maintain and to calibrate the equipment.

There are some weaknesses of the present study warranting discussion. First, the possibility exists that we may have overestimated or underestimated the effect of our intervention because of an error of omission. To minimize this possibility, we generated samplings of 100 consecutive iCa measurements to form our case populations. In this way, errors of omission resulting from an incomplete study population would be distributed by chance equally across all sampled subgroups (HIM, ED, ICUs, miscellaneous ordering departments). Additionally, we recognize that this is a convenience sample, and the lack of matching between preintervention and postintervention study populations might lead to potential biases and confounders that limit the strength of the conclusions. Last, educational interventions are known to have limited durability. It is unknown how durable the effect of our intervention will be beyond the 10 months of our follow-up assessment, and this remains to be determined.

CONCLUSION

Herein, we presented the results of a simple intervention based on clinician education and feedback to reduce the frequency of unnecessary routine iCa measurement. We were able to decrease routine iCa measurement by 66% ($p = 0.0007$) in participating HIM services. Even though unnecessary ordering was not eliminated, this reduction translates to cost savings and improved use of resources. Laboratory testing that is driven by clinical indication can improve the cost-effectiveness of daily clinical practice. In the current era of unprecedented challenges in health care systems worldwide, efforts to optimize the use of available resources should be encouraged. Simple educational interventions aiming at the elimination of ordering practices that are potentially harmful to patients and costly can be effective. ❖

Disclosure Statement

Dr Jaffe is a consultant for Bechman, Ortho, Alere, Abbot, Critical DX, Radiometer, Roche, Trinity, ET Healthcare, the American Heart Association, and Amgen. The author(s) report no other conflicts of interest to disclose.

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Destroy the Reason

Medicine [is] the only profession that labours incessantly
to destroy the reason for its own existence.

— James Bryce, Viscount Bryce of Dechmont, 1838-1922, British academic, jurist, historian, and Liberal politician