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Validation of the Use of Electronic Medical Records for Identification of Post-gastric Bypass Hypoglycemia Cases

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Abstract

Objective We sought to validate an algorithm designed to identify patients with post-gastric bypass hypoglycemia (PGBH) using clinician chart review.

Methods We conducted a chart review study of non-diabetic patients who underwent Roux-en-Y gastric bypass (RYGB) at our institution from 2004 to 2013. The electronic medical record (EMR) algorithm was based on any post-operative glucose <60 mg/dl, diagnosis of hypoglycemia, or medication use for treatment of PGBH and identified 158 charts as PGBH and 1048 charts without PGBH. Two clinicians independently reviewed a random selection of 80 cases and 80 control charts and determined the presence or absence of PGBH by searching the chart using keywords and reviewing laboratory results, medications, and clinic notes.

Results Of the 160 charts reviewed, the EMR algorithm agreed with the chart review for 130 (accuracy = 80%, 95% CI = 75–87%) with sensitivity of 89% (95% CI = 83–96%) and specificity of 86% (95% CI = 78–93%). We improved the algorithm's accuracy to 90% by limiting the search to data obtained 3 months or more following RYGB.

Conclusion The EMR algorithm has high sensitivity, specificity, and accuracy to identify post-gastric bypass hypoglycemia within our patient cohort. The use EMR-based algorithms may be a useful tool for future research to improve our understanding of epidemiology and risk factors for post-bariatric surgery hypoglycemia.

Keywords Bariatric surgery · Hypoglycemia · Electronic medical record · Validation

Introduction

With increasing utilization of bariatric surgery to treat obesity and its comorbidities, post-gastric bypass hypoglycemia (PGBH) has emerged as an important metabolic complication [1, 2]. Also known as late dumping syndrome, PGBH is thought to be due in part to an exaggerated insulin response to a carbohydrate-containing meal and can be potentially devastating with reports of seizure, syncope, and auto accidents [3, 4]. While prior studies based on hospitalization record or self-report suggested PGBH was a rare occurrence (< 0.1%), more recent studies suggest that this complication may be more common [5–7].

The advent of the electronic medical record (EMR) has enhanced our ability to identify cohorts of patients more easily for better understanding of disease prevalence and outcomes. Indeed, our group found a cumulative incidence of PGBH 13.1% at 5-year follow-up after gastric bypass and that the risk factors were lower preoperative body mass index and hemoglobin A1c and higher 6-month post-operative weight loss using the EMR data of non-diabetic patients who underwent gastric bypass at our medical center [8]. In planning for future use in research and clinical setting, we recognized the need to both assess and improve the accuracy of this method for identifying hypoglycemia. Thus, we aimed to evaluate the accuracy of the EMR algorithm in identifying

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patients with PGBH and identify any criteria that might result in lower accuracy.

Methods

This was a single-center, retrospective study based on clinician-led chart reviews and the EMR data available within our health systems (Danville, PA, USA). As previously reported, we used a clinical registry for bariatric surgery patients at our medical center, which was established in 2004 with regularly scheduled data transfers from its EMR to the registry for longitudinal data collection [8]. The details of the clinical registry and its interface with the EMR have been previously described [9]. This study was approved by the Institute Review Boards of our medical center. All study participants provided written informed consent for inclusion into the registry. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

As we have previously reported, we identified a total of 1206 individuals without diabetes or hypoglycemia prior to surgery who underwent RYGB at our medical center between 2004 and December 2014. We defined PGBH using EMR data as (1) measured plasma glucose less than 60 mg/dl; (2) any post-operative outpatient or inpatient encounter with a diagnosis of hypoglycemia: International Classification of Diseases 9 (ICD9) 251.0–251.3; or (3) prescription order or active medication use for treatment of PGBH occurring at least 1 month after surgery (acarbose, glucagon, diazoxide). Severe hypoglycemia was defined as any plasma glucose < 40 mg/dl, any visit to the Emergency Department (ED), visit or hospitalization due to hypoglycemia, or gastric bypass reversal due to hypoglycemia (Fig. 1).

In this study, two clinician reviewers independently reviewed 80 randomly selected charts from the 158 cases and additional 80 charts randomly selected from 1048 which did not develop PGBH. In case of disagreement between the two reviewers, the reviewers discussed their rationales and achieved agreement. If the disagreement remained after the discussion, we planned for a third reviewer to review and make the determination. Data was abstracted using a standardized form, which contained questions prompting the reviewers to look for the following clinical information in each chart: evidence of pre-existing hypoglycemia, exact cause of hospitalization or ED visit due to confusion, syncope, or seizure, glucose measurements not captured in our preliminary data analysis (e.g., emergency medical technician record during transportation to the ED or any record of self-monitored glucose values or continuous glucose monitor data), or

record of treatment of hypoglycemia such as dextrose, glucose tablet, or glucagon.

Statistical Methods

We summarized the data using basic descriptive statistics. We determined the accuracy of each criterion used to identify PGBH cases by calculating the estimated point estimates for sensitivity, specificity, and positive and negative predictive values.

Results

There were 1206 patients without pre-existing diabetes who underwent gastric bypass between 2004 and 2014 at our medical center. The group was mostly female (86%) with a mean age of 43.7 years and a mean preoperative BMI of 48.7 kg/m². As previously reported, a total of 158 patients among the 1206 patients met the electronic medical record (EMR) criteria for post-gastric bypass hypoglycemia (PGBH) and these had a lower preoperative BMI and hemoglobin A1C and longer follow-up time compared with the overall group [8]. Among the 158 charts that met the EMR criteria for PGBH, the baseline characteristics were similar between the randomly selected 80 charts and the remaining 78 charts. Similarly, among the 1048 charts that did not meet the EMR criteria for PGBH, the baseline characteristics were comparable between the randomly selected 80 charts and the remaining 968 charts (Table 1, Fig. 1).

Of the 160 charts reviewed, the EMR algorithm agreed with the chart review for 130 (accuracy = 80%, 95% CI = 75–87%). Of the 76 charts confirmed to have PGBH based on chart review, 68 were positive for PGBH and 8 were false negative from the EMR algorithm (sensitivity = 89%, 95% CI = 83–96%). Of the 84 charts confirmed to not have PGBH based on chart review, there were 72 that were negative for PGBH and 12 were false positive from the EMR algorithm (specificity = 86%, 95% CI = 78–93%) (Fig. 1).

We improved the accuracy of the EMR algorithm from 80 to 90% by limiting the ICD codes to those detected 3 months or more following the gastric bypass. This allowed us to exclude cases of hypoglycemia occurring shortly after the surgery in setting of poor oral intake and not due to post-prandial hypoglycemia that characterizes PGBH. We also came across a new ICD9 code of 579.3 (hypoglycemia post-gastrointestinal surgery) during chart review, but the addition of this ICD9 code to our EMR algorithm did not yield new cases. Interestingly, the accuracy of the EMR algorithm was increased to 91% when we excluded the use of certain medications (i.e., acarbose, glucagon, diazoxide) from the algorithm (Table 2).
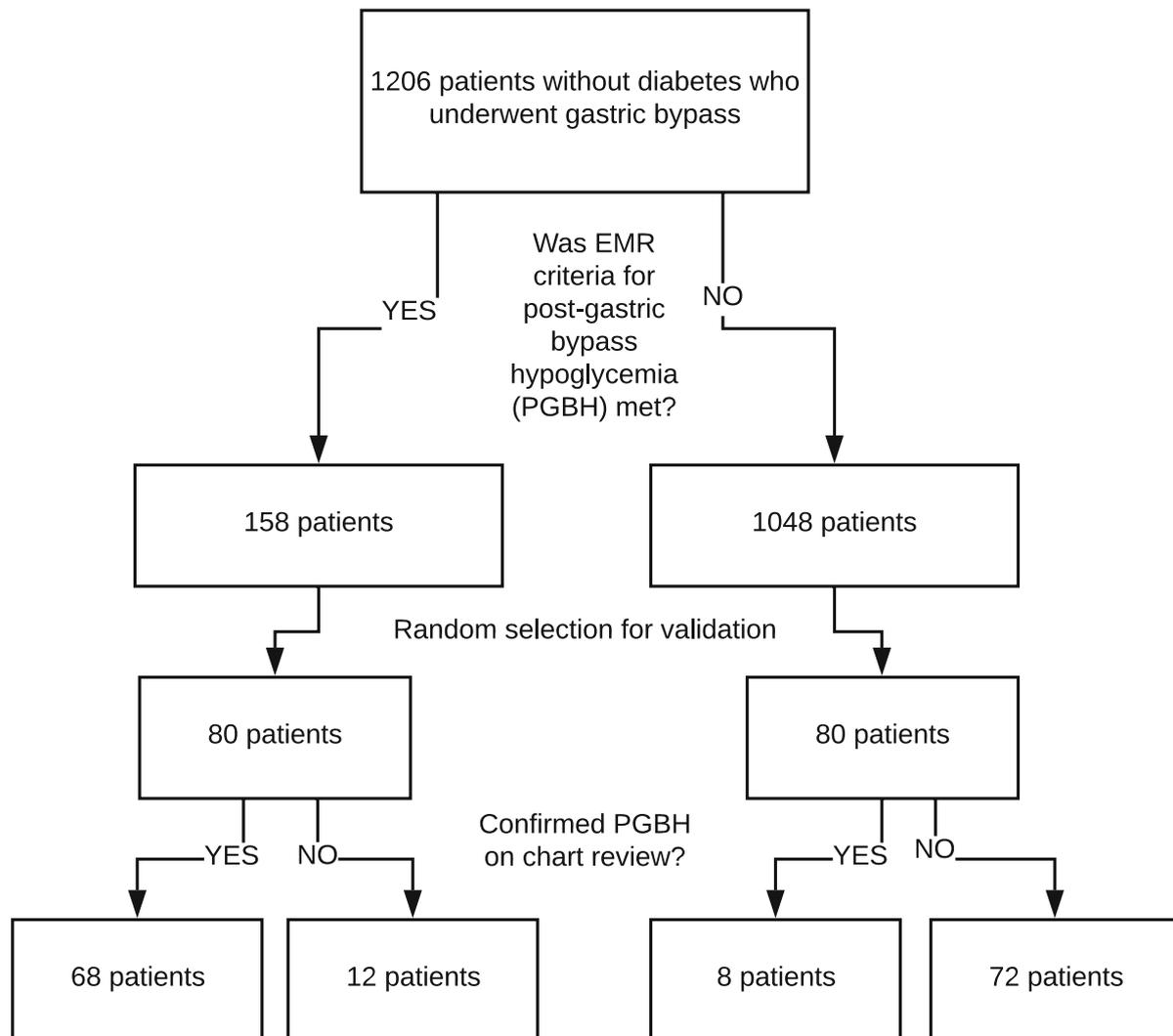
Fig. 1 Flow diagram of patient chart selection for chart review and outcomes

Reasons for Discordance

Among the 13 charts that were false positives (i.e., categorized as PGBH cases per EMR algorithm and confirmed as non-cases per chart review), the reasons were diagnosis of hypoglycemia that preceded the date of gastric bypass (6 charts), plasma or fingerstick glucose less than 60 mg/dl within weeks of the surgery (3 charts) or without additional supporting documentation (1 chart) and use of medication such as octreotide for reasons other than treatment of hypoglycemia (3 charts). Specifically, one post-gastric bypass patient was given octreotide to reduce gastric output during a revisional surgery. Among the 9 charts that were false negatives (i.e., categorized as non-cases per EMR algorithm and confirmed as PGBH cases per chart review), the reasons were self-reported episodes of hypoglycemia found in clinic or ED notes (6 charts), missed glucose data (lab collected after our initial EMR search, 1 chart), self-report of PGBH diagnosis found in clinic

note (1 chart), and new onset syncope after gastric bypass noted in ED note (1 chart).

Severity of Confirmed Cases

Of the 76 cases confirmed by chart review, 65 had their severity level previously determined based on an EMR-based definition of a severe case as presence of any glucose < 40 mg/dl, any visit to the Emergency Department (ED), or visit or hospitalization due to hypoglycemia. In chart review, we used a broader definition for a severe case given the ability to examine a wider array of data including clinic notes—needing medical attention such as ED or inpatient hospitalization, evidence of neuroglycopenic symptoms (confusion, drowsy, odd behavior, slurred speech, or incoordination) or glucose < 40 mg/dl. Using this broader definition, we found 39 charts (39/65 or 60%) as severe cases. Of the 39 severe cases

Table 1 Baseline characteristics of 1206 non-diabetic patients who underwent gastric bypass at our medical center stratified by presence of hypoglycemia and whether they were selected for chart review

Characteristics	Overall population	Incident hypoglycemia			No hypoglycemia		
	$N = 1206$	Selected $N = 80$	Not selected $N = 78$	p value	Selected $N = 80$	Not selected $N = 968$	p value
Age, mean [range]	43.7 (10.5) [18, 72]	43.2 (10.1) [18, 68]	44.9 (10.0) [25, 65]	0.290^1	43.1 (10.2) [21, 72]	43.7 (10.6) [19, 72]	0.644^1
Sex, female % (n)	86% ($n = 1032$)	94% ($n = 75$)	85% ($n = 66$)	0.064^2	84% ($n = 67$)	85% ($n = 824$)	0.741^2
Male % (n)	14% ($n = 174$)	6% ($n = 5$)	15% ($n = 12$)		16% ($n = 13$)	15% ($n = 144$)	
Preoperative BMI (kg/m^2)	48.7 (8.2) [35.0, 94.3]	47.8 (7.7) [35.0, 75.0]	46.4 (6.9) [35.5, 67.3]	0.219^1	48.9 (8.0) [36.0, 78.8]	49.0 (8.4) [35.0, 94.3]	0.918^1
Preoperative Hemoglobin A1C (%)	5.6 (0.4) [4.1, 6.4]	5.5 (0.4) [4.5, 6.2]	5.5 (0.3) [4.4, 6.4]	0.839^1	5.6 (0.4) [4.3, 6.4]	5.6 (0.4) [4.1, 6.4]	0.479^1
Follow-up time (years)	4.8 (2.8) [< 0.1, 11.2]	6.1 (2.3) [0.5, 11.1]	6.0 (2.4) [1.4, 11.2]	0.916^1	4.4 (3.0) [< 0.1, 10.7]	4.6 (2.8) [< 0.1, 11.1]	0.430^1
6-month post-surgical IBWL (%)*	29.7 (5.5) [7.2, 51.1]	30.0 (5.8) [13.8, 51.1]	30.2 (5.8) [17.8, 44.0]	0.853^1	30.0 (5.1) [21.8, 47.3]	29.6 (5.5) [7.2, 47.4]	0.567^1

[1] Two-sample t test, [2] Chi-square test, [3] Fisher's exact test

BMI body mass index, *IBWL* initial body weight loss

confirmed on chart review, only 4 previously were determined as severe on EMR algorithm.

Discussion

To our knowledge, this is the first study that validated an algorithm used to identify patients with high likelihood of physician-documented post-gastric bypass hypoglycemia based on electronic medical record data. In our prior work, we established an algorithm to identify post-gastric bypass hypoglycemia based on measured glucose below 60 mg/dl, ICD codes, and/or medication use such as acarbose or diazoxide following the index surgery [8]. In this study, two clinicians independently reviewed select case and control charts using a standard abstraction form and confirmed that the algorithm had high sensitivity, specificity, and accuracy.

Furthermore, we were able to improve the accuracy of the algorithm by restricting the EMR search period to at least 3 months after the index surgery. By doing so, we were able to eliminate a few cases of hypoglycemia within days to weeks of index surgery that occurred in setting of limited oral intake or infection and not specifically due to PGBH.

Interestingly, many of the charts thought to have non-severe PGBH based on the EMR algorithm were found to be severe based on chart review. This may be in part due to the broader definition of a severe case used during the chart review made possible by the ability of the reviewers to search through clinical documents and to incorporate relevant data within the text to help determine the case severity more accurately. The fact that many of the confirmed cases of PGBH based on chart review are severe cases further underscores the need for further research in understanding the epidemiology and mechanisms of PGBH. On the other hand, several charts

Table 2 Comparison of sensitivity and specificity by various definitions from improved electronic medical record algorithm

Electronic algorithm definition	No. of true positives	No. of false negative	Sensitivity	No. of true negative	No. of false positive	Specificity	Overall accuracy
Glucose < 60 mg/dl only	34	42	45%	83	1	99%	73%
Diagnosis only	40	36	53%	80	4	95%	75%
Med treatment only	10	66	13%	82	2	98%	58%
Glucose < 60 mg/dl + diagnosis	66	10	87%	79	5	94%	91%
Glucose < 60 mg/dl + meds	41	35	54%	81	3	96%	76%
Diagnosis + meds	43	33	57%	78	6	93%	76%
Glucose < 60 mg/dl + diagnosis + meds	67	9	88%	77	7	92%	90%

were falsely identified as cases per algorithm based on ICD code for hypoglycemia that were documented prior to the bariatric surgery. Upon detailed review of these charts, most were clearly non-cases given that there were no further evidence of hypoglycemia after the gastric bypass. However, a few cases remained unclear whether the continued symptoms of hypoglycemia post-surgery were worse and perhaps suggestive of post-gastric bypass hypoglycemia. However, we found insufficient data in these charts to adjudicate them as cases. We have previously reported that pre-existing symptoms of hypoglycemia are risk factors for post-gastric bypass hypoglycemia, and therefore future prospective studies are warranted to examine this link [8].

The fact that our EMR-based algorithm had high accuracy upon validation by chart review has several implications; first, we have demonstrated through this study that a well-established longitudinal EMR can serve as a powerful and practical tool to identify otherwise under-recognized patient cohorts. The development and validation of EMR-based algorithms are important in future research as they are potentially reproducible tools that can be used to reliably identify otherwise under-recognized patient cohorts across different healthcare settings. Indeed, the rising use of EMR across the country has fostered recent studies reporting the use of EMR-based algorithms to identify patients with a variety of diseases including hypoglycemia in adults with diabetes, sickle cell disease, rheumatoid arthritis, and insomnia [10–13]. Furthermore, EMR-based algorithms have been successfully used to identify large numbers of disease cases and non-disease controls needed to sufficiently power genetic studies across multiple institutions [14]. The mechanism behind PGBH is thought to be multifactorial including altered gut hormone secretion, insulin sensitivity, and insulin clearance [4, 15–18]. By better identifying PGBH using an EMR-based algorithm, we can begin to understand the epidemiology and mechanisms involved in PGBH.

Second, our algorithm has the potential to be used in clinical settings at the time of follow-up visits to assess the patient's risk for PGBH and to guide patient-physician discussion and therapeutic plans after bariatric surgery. In general, use of EMR data in healthcare settings allows for not only algorithm application for identifying disease cohorts but also for potential future studies to obtain data on disease progression and outcomes. Third, our prior observation that the 5-year incidence of post-gastric bypass hypoglycemia at our institution was 13.3% is further supported by this validation study. In addition, prior studies reporting a wide range of PGBH prevalence as well as the rising utilization of bariatric surgery around the country underscore the need for future prospective studies to better understand the epidemiology of PGBH [5, 6, 19, 20].

The strengths of this study include the use of a well-characterized bariatric surgery cohort with longitudinal follow-up data captured within a large database of our healthcare system, use of standardized form to perform the chart review, and duplicate chart reviews carried out by two independent clinician reviewers. However, the current study also has some limitations. The blood glucose data captured in our algorithm are plasma glucose values and not capillary glucose values or self-reported glucose values. We only reviewed a select portion of the case and control charts. We did not validate our algorithm in other clinical settings, and therefore our findings may not be generalizable in other settings such as tertiary medical centers with limited long-term follow-up patient post-bariatric surgery. We also focused solely on gastric bypass cases, and thus the utility of this algorithm is unknown for patients who underwent other types of bariatric surgery.

Conclusion

Our electronic medical record-based algorithm has high sensitivity, specificity, and accuracy to identify post-gastric bypass hypoglycemia within our patient cohort. Future studies are warranted to validate this algorithm in other cohorts of post-bariatric surgery patients. Ultimately, the use of electronic medical record-based algorithms may be a useful tool to accelerate further research in this field with the goal of improving our understanding of epidemiology and risk factors for post-bariatric surgery hypoglycemia, as well as improve clinical care of these patients.

Compliance with Ethical Standards

This study was approved by the Institute Review Boards of our medical center. All study participants provided written informed consent for inclusion into the registry. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflict of Interest CJL has consulted for XOMA and Xeris Pharmaceuticals and has been a site investigator for Eiger Pharmaceuticals. The rest of the authors have nothing to disclose.

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