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ML/AI for predicting complications after bariatric surgery

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Abstract

Artificial intelligence (AI) is being utilized with increased frequency in the medical field, and this is the case with metabolic bariatric surgery (MBS). One of the potential utilities of AI algorithms is their role as predictive tools for postoperative complications following MBS. In this review, we attempt to accumulate the existing evidence in this field. The PRISMA statement will be followed to retrieve pertinent literature. The retrieved studies along with their key findings and metrics (including sensitivity, specificity, accuracy, and area under the receiver operating characteristic curve) will be tabulated and summarized. There will be a discussion on the utility of our findings, as well as on how they compare to existing evidence in bariatrics and other disciplines.

Introduction

- 1 The integration of artificial intelligence (AI) and machine learning (ML) into healthcare has been transformative, with their applications in surgery growing exponentially. These technologies are now leveraged for preoperative planning, intraoperative guidance, and postoperative monitoring, significantly enhancing surgical precision and decision-making. In the field of metabolic bariatric surgery, AI and ML algorithms have shown promise in areas such as patient selection, outcome prediction, and complication identification, paving the way for a new era of personalized and data-driven surgical care [1], [2], [3].

Over the years, the safety profile of metabolic bariatric surgery has markedly improved, thanks to advancements in surgical techniques, optimization of perioperative protocols, and the evolution of surgical equipment. Accumulated experience among bariatric surgeons has also contributed to reducing complications, leading to better patient outcomes. As a result, procedures such as sleeve gastrectomy and Roux-en-Y gastric bypass have become safer and more widely accepted as effective interventions for managing obesity and its associated comorbidities. For instance, according to a review published almost a decade ago, bariatric surgery is safer than most operations deemed as “routine”, including laparoscopic cholecystectomy, appendectomy, and colectomy [4]. Similar findings have been confirmed in the most recent joint ASMBS/IFSO guidelines for bariatric surgery, where a perioperative mortality of 0.03–0.2% is documented [5].

Despite these advancements, the potential for complications persists, making postoperative monitoring and risk stratification critical. Here, AI and ML present an exciting frontier. By analyzing vast datasets of patient characteristics, surgical details, and outcomes, these technologies can identify patterns and predict complications with remarkable accuracy. This predictive capability could enable early intervention and better allocation of resources, ultimately improving patient safety and long-term outcomes.

In this context, exploring the application of AI in predicting complications following metabolic bariatric surgery offers significant potential. By systematically reviewing the current literature on this topic, we aim to synthesize evidence on the utility of AI and ML in enhancing postoperative care for bariatric patients. This approach will help identify gaps in existing knowledge, highlight promising applications, and provide a roadmap for future research to optimize outcomes and further improve the safety profile of metabolic bariatric surgery in an era of rapidly advancing medical technology.

Methods

- 2 This systematic review and meta-analysis will be performed according to the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) guidelines to investigate the utility of ML and other applications of AI in predicting complications after metabolic bariatric surgery (MBS) [6]. The PICOS acronym will be used to outline the study eligibility criteria:
- Population (P): individuals living with obesity, with ages ranging between 18 and 65 years, who had undergone metabolic bariatric surgery of any type [including but not limited to laparoscopic sleeve gastrectomy (LSG); Roux-en-Y gastric bypass (RYGB); one-anastomosis gastric bypass (OAGB); single anastomosis duodenal switch with sleeve gastrectomy (SADI-S); and adjustable gastric banding (AGB), unless it was the only bariatric intervention studied], either index or revisional.
 - Intervention (I): implementation of machine learning (supervised and unsupervised), deep learning, or any other AI algorithm to predict and analyze complications occurring postoperatively, within 90 days (early), or at a later phase (late).
 - Comparison (C): comparison of the performance of the examined AI algorithm(s) with conventional and established (if applicable) predictive tests is desired but not mandatory.
 - Outcomes (O): performance of the examined algorithm(s), as documented by the metrics mentioned in each study (sensitivity, specificity, area under the receiver operating characteristic curve, etc.); comparison to the performance of an established "conventional" predictive algorithm was desirable but not mandatory.
 - Study design (S): retrospective and prospective studies with any number of participants.

2.1 Literature Search Strategy

A systematic literature search of the electronic databases PubMed (MEDLINE) and Google Scholar will be performed by two independent reviewers (AGP, PE). We will divide the search terms into 3 groups. Group A will be relevant to MBS and include the terms "bariatric", "gastric band*", "sleeve", "gastric bypass", "duodenal switch", and "SADI". Group B will include terms pertinent to postoperative complications and comprised the following terms: "complications", "adverse events", "morbidity", "leak*", "erosion", "hemorrhage", "bleeding", "chole*", "fever", "infect*", "thrombosis", "embolism", "pneumonia", "respiratory", "cardiovascular", "infarction", "kidney", "renal", "acute", "nutritional deficien*", "anemia", "calcium", "vitamin", "reflux", "GERD", "failure", "hernia", "weight recurrence", and "readmission". Finally, Group C will contain terms relevant to AI algorithms, such as "artificial intelligence", "machine learning", "deep

learning", "natural language processing", and "neural network". Each term from groups A, B, and C will be combined with each other using the Boolean operators AND or OR. We will scrutinize the reference lists of the included studies to retrieve additional studies that could potentially be included in our analysis. The search will be limited to English literature until November 2024.

2.2 Study Selection

We will consider all studies published in the English language until November 2024. The studies should have been performed on human populations. Duplicate search results will be removed before screening for eligibility according to abstracts. In our analysis, we will include only primary studies, as such reviews (narrative, scoping, systematic reviews, and meta-analyses), as well as case reports, editorials, letters to the editor, and commentaries will be excluded. We will only include studies the full text of which can be accessed. As such, conference abstracts were also excluded. Studies referring to education and the learning curve of bariatric procedures, robotic surgery, comorbidities (including major adverse cardiovascular events as comorbidities of obesity rather than postoperative complications), quality of life, bariatric outcomes (weight loss, resolution of diabetes and other obesity-related health problems), obesity in general (without the implementation of bariatric surgery), complications of endoscopic interventions (including endoscopic sleeve gastropasty), and computer vision analysis will also be excluded. The full texts of the remaining studies will be retrieved for further evaluation by 2 independent reviewers (AGP, PE). Selection discrepancies between the two reviewers will be resolved through discussion and in case no consensus can be reached, a third researcher (DPL) will make the final decision. The study selection process will be illustrated in a PRISMA flowchart. A supplementary table will summarize the excluded studies at the phase of eligibility (i.e. after screening) with reasoning.

2.3 Risk of Bias Assessment

The PROBAST risk of bias (RoB) tool will be independently applied to each study by 2 reviewers (AGP, PE) to assess the methodological quality included in the ML and the rest of the AI models implemented [7]. This tool is designed to evaluate the RoB in four categories (participant selection, predictors, outcomes, and analysis) and consequently yield an overall RoB assessment, according to these 4 categories.

2.4 Data Extraction

The included studies will be referenced using Zotero (Corporation for Digital Scholarship), and Microsoft Excel will be used during the screening and data extraction process. Data will be extracted by 2 independent reviewers (AGP, PE) into an Excel spreadsheet for the following parameters: first author;



year of publication; country/-ies of the institution (s) involved; doi number (or PMID if doi number was missing); type of complication; type of surgery; study design (retrospective or prospective); prediction (whether the examined algorithm was prognostic or diagnostic); total cohort population; number of complications; size of training, test, and validation datasets; top-ranked variables (features); AI algorithms studied; method of dealing with imbalance; and metrics, including accuracy, sensitivity, specificity, F1-score, area under the receiver operating characteristic curve (AUROC), area under the precision-recall curve (AUPRC), positive predictive value (PPV), and negative predictive value (NPV).

2.5 Data Synthesis

A descriptive summary will be utilized to outline the types of ML/AI models organized by type of complication post-MBS. The discriminative ability of each algorithm will be represented by describing the sensitivity, specificity, and AUROC for the models corresponding to each outcome, wherever these metrics are available.

Results

- 3 The results will be presented in an organized fashion, categorized by type of complication. A cumulative table will summarize the key characteristics and findings from each primary study.

Discussion

- 4 The findings of our synthesis will be critically appraised and compared to similar research in bariatric surgery or other surgical fields.

Conclusion

- 5 A 2-3-sentence conclusion paragraph will summarize the findings of our study and propose future directions for relevant research.

Declarations

- 6 This section will include ethical and financial disclosures.

Literature

- 7 [1] A. G. Pantelis, G. K. Stravodimos, and D. P. Lapatsanis, 'A Scoping Review of Artificial Intelligence and Machine Learning in Bariatric and Metabolic Surgery: Current Status and Future Perspectives', *Obes. Surg.*, vol. 31, no. 10, pp. 4555–4563, Oct. 2021, doi: 10.1007/s11695-021-05548-x.
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PLUS

The primary studies included in our analysis.

PLUS

Similar studies in the literature.