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AI-Enhanced Postoperative Monitoring and Prediction of Complications after MBS

From static risk scores to dynamic, complexity-aware AI

Athanasios G. Pantelis, MD, MSc, FMBS, FACS

Consultant General & Bariatric Surgeon,
Obesity and Metabolic Disorders Department, Athens Medical Group, Psychiko Clinic, Athens, Greece
Scientific Collaborator, National & Kapodistrian University of Athens

No conflicts of interest to declare

ACT I OF 3

The Problem

Why static risk prediction (old and new) has plateaued in metabolic bariatric surgery

Rare complications, disproportionate consequences

0.70%

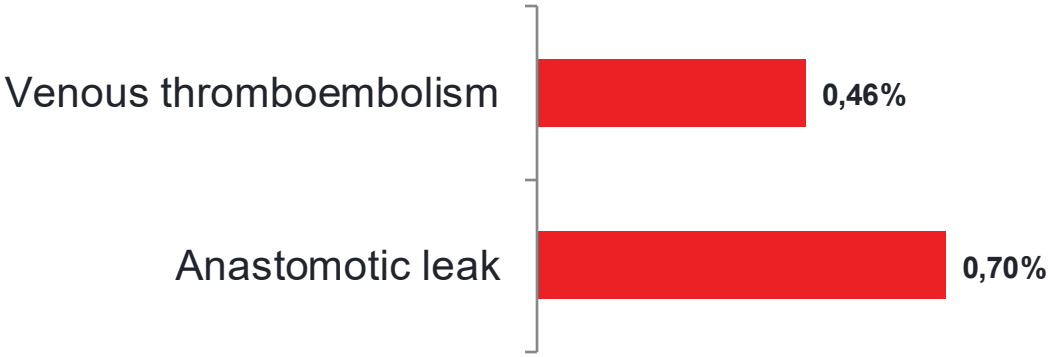
Anastomotic leak incidence: 436,807 pts in the MBSAQIP database.

0.46%

VTE incidence, same cohort.

>$100,000

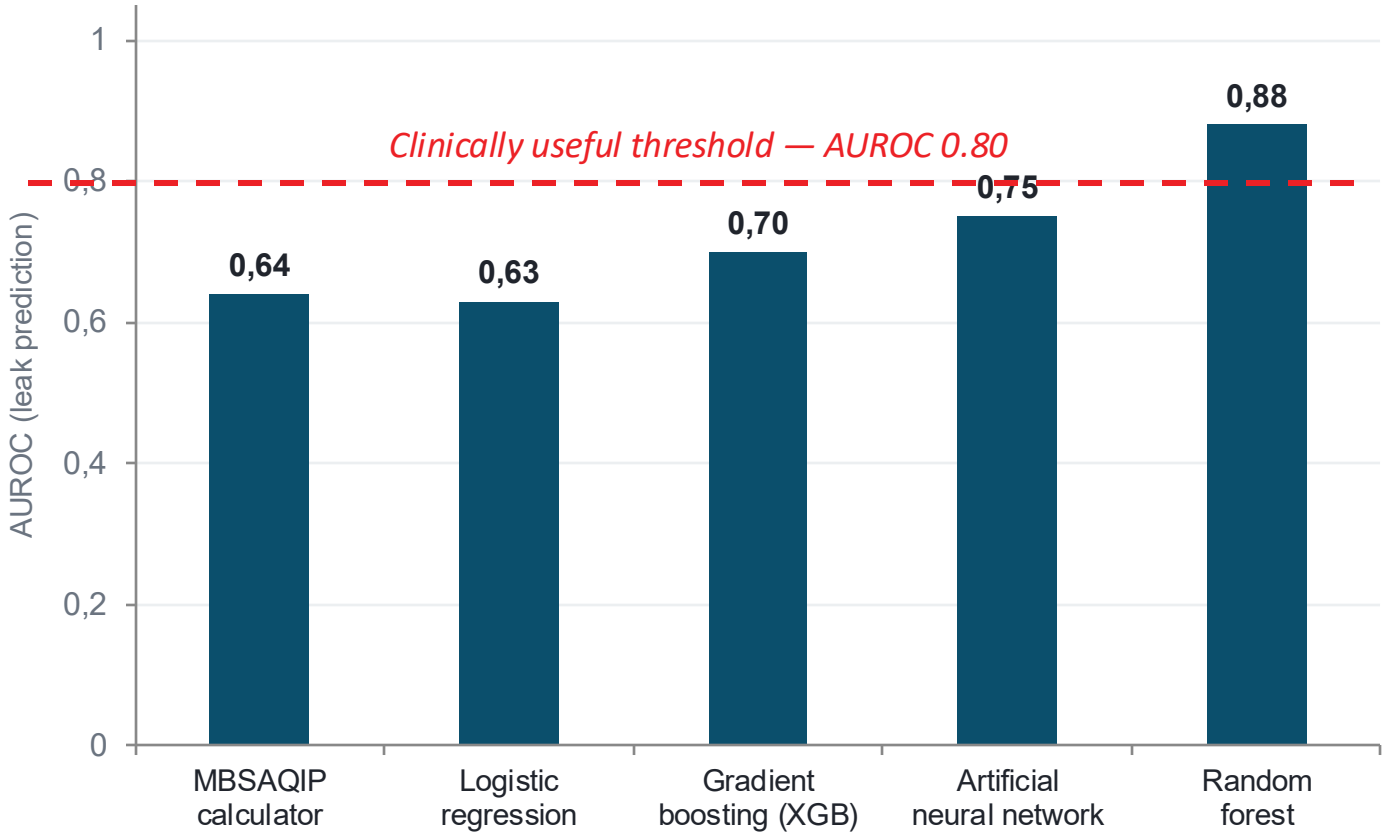
Average cost of a single leak, before accounting for mortality risk.



Yet these are exactly the outcomes patients, surgeons, and payers care about most — and the outcomes traditional risk tools predict worst.

Nudel et al. Surg Endosc 2021; Nedelcu et al. Surg Endosc 2017

Static risk calculators barely beat chance



What this means

- MBSAQIP risk calculator: AUROC 0.63 - 0.64 for leak → barely better than chance
- Even top ML models (ANN, XGB) plateau at 0.70–0.75
- An AUROC of 0.75 still misclassifies roughly 1 in 4 patient pairs
- All are built on static, preoperative, tabular data

Nudel et al., Surg Endosc 2021

Mapping the evidence: 1,398 records → 23 studies

Pantelis *et al. Art Int Surg.* 2025;5:322-44
DOI: 10.20517/ais.2024.104

Artificial Intelligence Surgery

Systematic Review

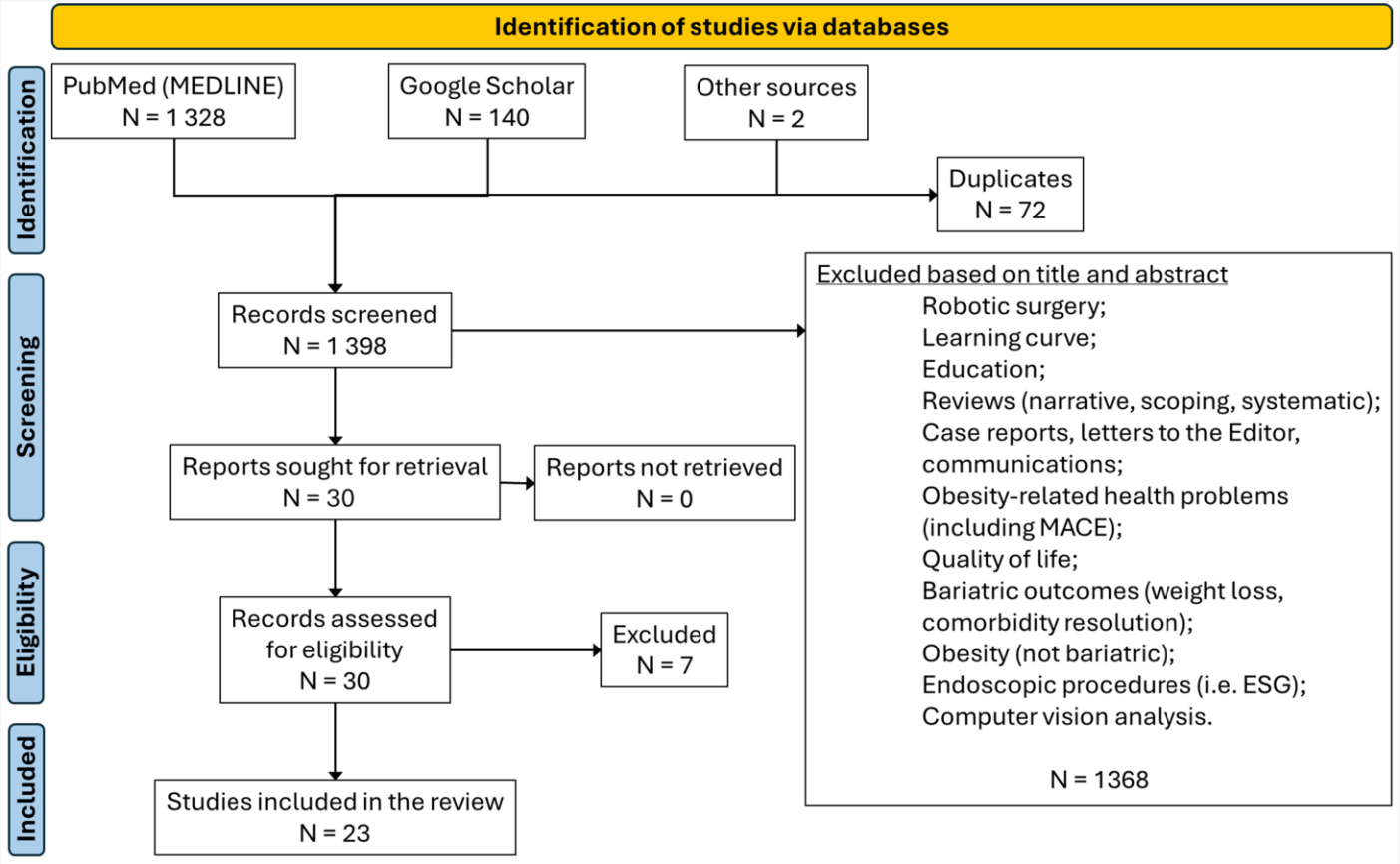
Open Access

Check for updates

Machine learning and artificial intelligence for predicting short and long-term complications following metabolic bariatric surgery - a systematic review

Athanasios G. Pantelis, Panagiota Epiphaniou, Dimitris P. Lapatsanis

Mapping the evidence: 1,398 records → 23 studies



23

primary studies, 2007–2024

87

AI/ML algorithms analyzed

0.94

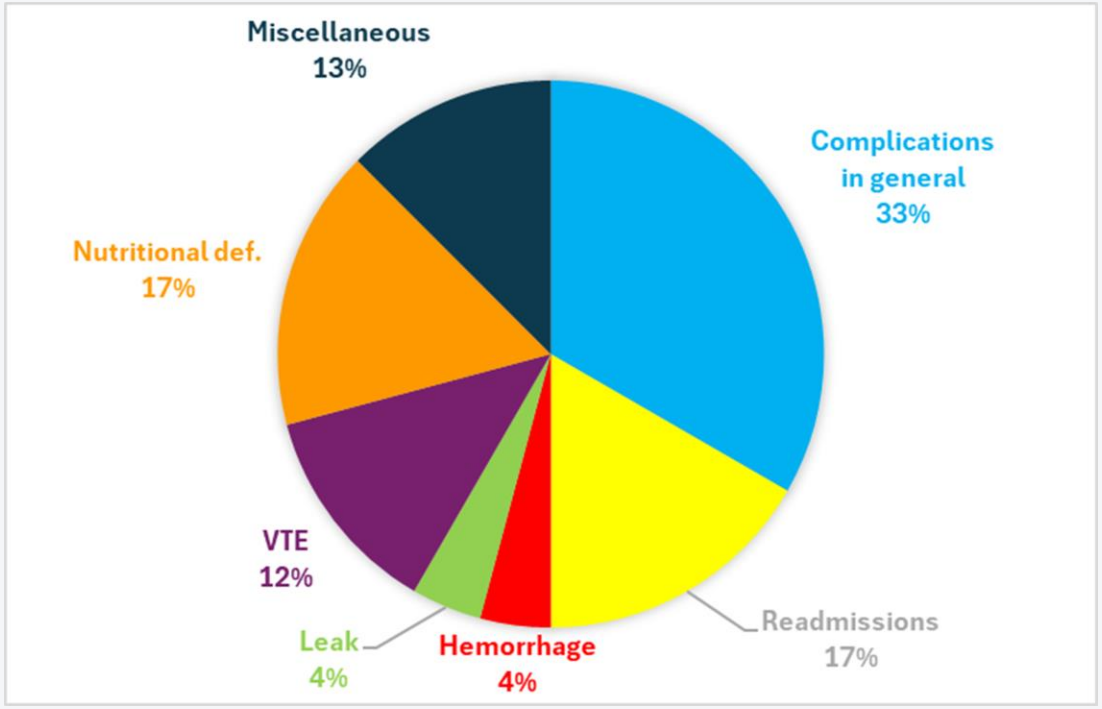
highest AUROC reported

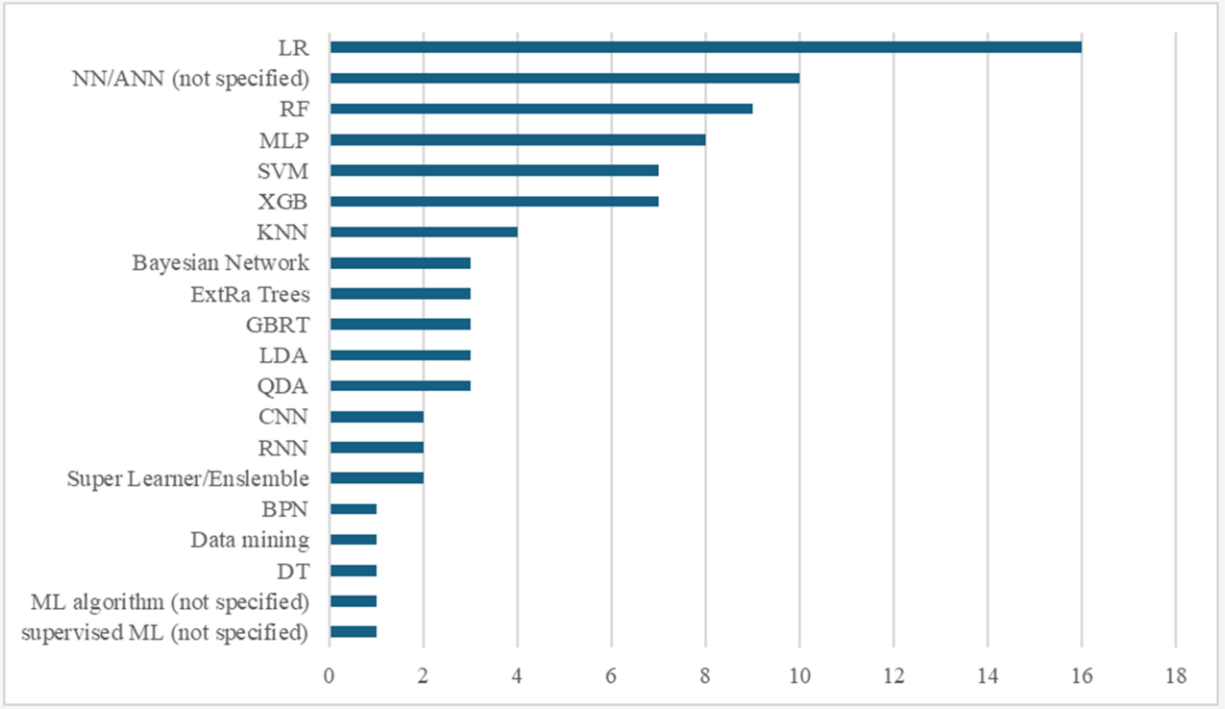
< 20%

of models cleared the 0.80 clinical-utility bar

Pantelis et al., Art Intel Surg 2025;5:322-344

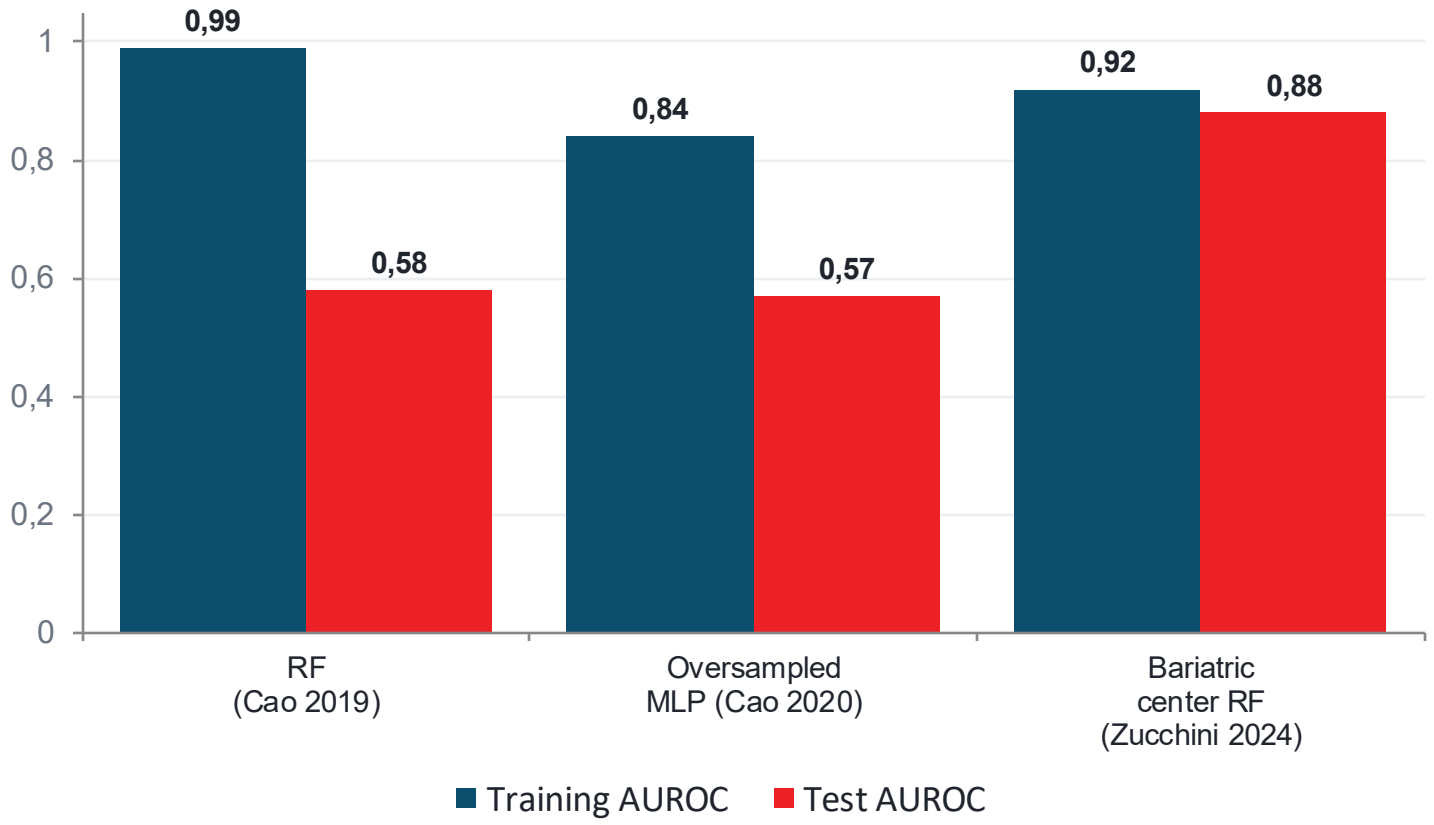
Where the effort went — and what tools were used





Pantelis et al., Art Intel Surg 2025;5:322-344

Great in training, poor in the real world



Why the drop?

- Complication rates under 1% force heavy oversampling (SMOTE), which can inflate training performance
- Models memorize noise in small, single-center cohorts rather than generalizable signal
- External validation is rare across the 23 reviewed studies
- Zucchini et al. is the exception — a smaller drop, still ahead of MBSAQIP (0.64)

Cao et al., J Clin Med 2019 & JMIR Med Inform 2020; Zucchini et al. Obes Surg 2024

Since our review closed

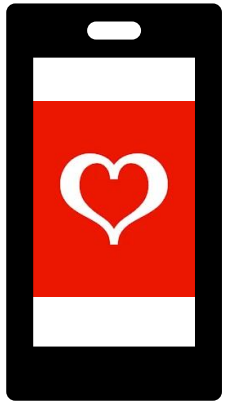
Obesity Surgery (2025) 35:2202–2209
https://doi.org/10.1007/s11695-025-07894-6

RESEARCH

Integrating Machine Learning and Dynamic Digital Follow-up for Enhanced Prediction of Postoperative Complications in Bariatric Surgery

Eleonora Farinella[1,2] · Dimitrios Papakonstantinou[1] · Nikolaos Koliakos[1] · Marie-Thérèse Maréchal[1] · Mathilde Poras[1] · Luca Pau[1] · Otmane Amel[2] · Sidi Ahmed Mahmoudi[2] · Giovanni Briganti[2]

Received: 5 February 2025 / Revised: 29 March 2025 / Accepted: 23 April 2025 / Published online: 2 May 2025



Dynamic beats static

- Preop-only model: AUC 0.647
  + real-time postop app data: AUC 0.715
- Best model used just 6 pt-reported items (vomiting, pain, intake, alerts); NO BIOSIGNALS!
- All-variable model overfit to AUC 0.627; trimming to 6 features fixed it
- Still below the 0.80 threshold

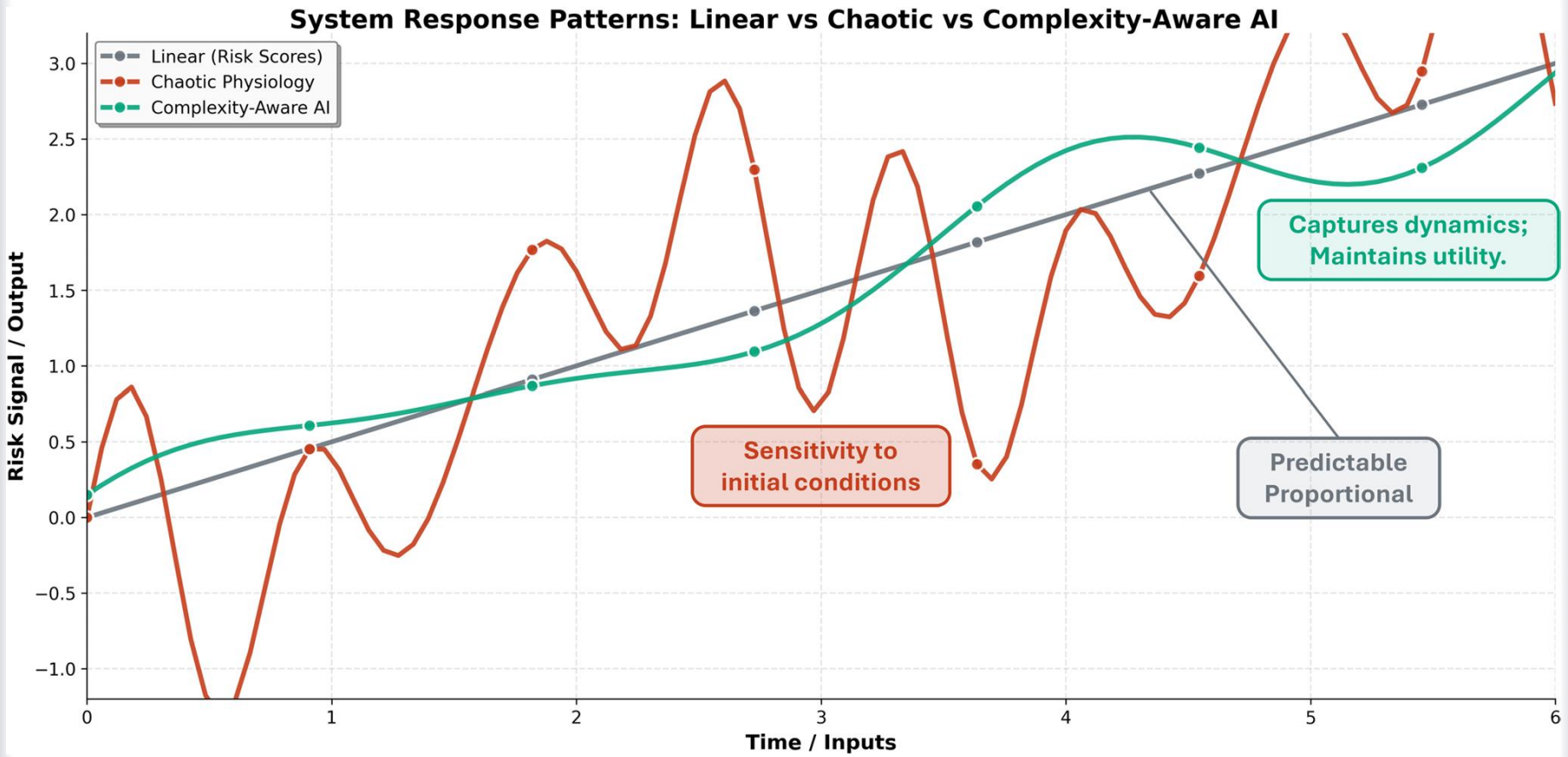
Farinella et al. Obes Surg 2025;35:2202-2209

ACT II OF 3

The Shift

From treating variability as noise to treating it as the earliest available signal

We treat patients as points. Physiology behaves like this ⤵



Obesity Surgery
https://doi.org/10.1007/s11695-026-08666-6

MBS triggers a rapid physiologic cascade

HOURS

Ghrelin plummets

DAYS

GLP-1 & PYY surge

WEEKS

Insulin sensitivity transforms

MONTHS

Bile acid signaling reconfigures

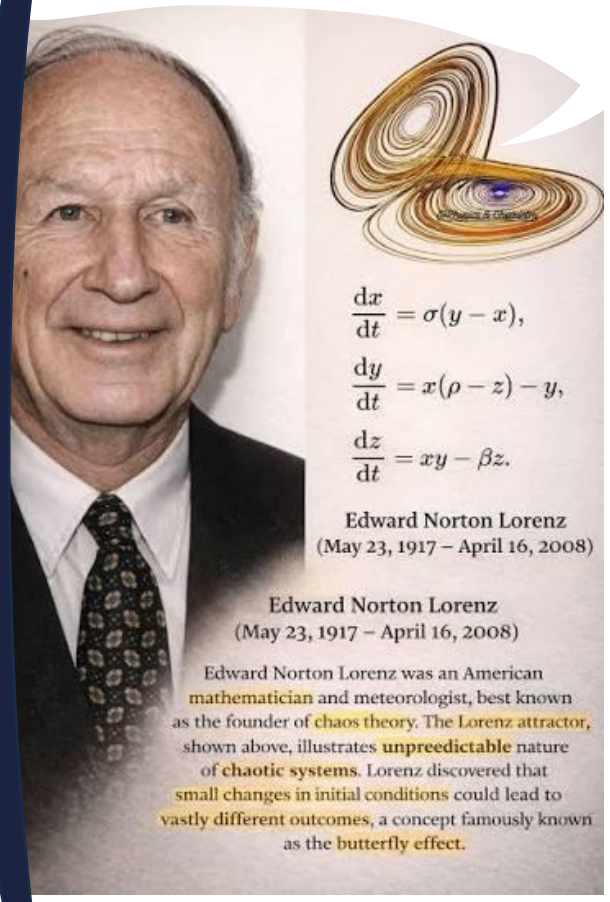
Patients with near-identical baseline characteristics diverge sharply after surgery.

MBS triggers a rapid physiologic cascade

- Small differences in initial conditions (errors in measurements, rounding in numerical computation) can yield widely **diverging** outcomes.
- **Long-term prediction** of the behavior of these dynamic systems **is impossible** in general.
- This can happen even though these systems are **deterministic**, i.e., their future behavior is fully *determined* by their **initial conditions**.
- Despite the deterministic nature of these systems, this **does not make them predictable**.
- This behavior is known as deterministic chaos, or simply **chaos**.

Source: Wikipedia

MBS triggers a rapid physiologic cascade



"Chaos is

when the present determines the future

BUT the *approximate* present does not

***approximately* determine the future"**

Lorentz E. The Essence of Chaos. University of Washington Press. ISBN 978-0-295-97514-6

MBS triggers a rapid physiologic cascade

HOURS	DAYS	WEEKS	MONTHS
Ghrelin plummets	GLP-1 & PYY surge	Insulin sensitivity transforms	Bile acid signaling reconfigures

Patients with near-identical baseline characteristics diverge sharply after surgery.

This is precisely what makes MBS a natural proving ground for complexity-aware monitoring: the physiologic signal changes faster, and more informatively, than in almost any other elective operation.

Wearables can catch deterioration early

Continuous remote early-warning score (CREWS)

A wearable biosensor (Healthdot) tracking heart rate and respiratory rate continuously for 7 days post-MBS, validated across a series of Dutch prospective studies (van Ede et al.)

75%

Sensitivity for detecting leak & hemorrhage (HR >110 bpm, RR >20)

98%

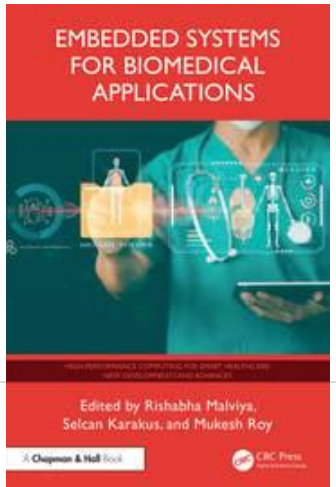
Specificity in real-world deployment across 102 patients

61%

Reduction in hospitalization days with same-day discharge protocol

Not yet a substitute for clinical judgment

- False positive rate up to 70% in real deployment
- Adherence drops over time: 56–97% across studies
- Vital-sign deterioration is often late in young, resilient bariatric patients
- Best used as an adjunct that triggers reassessment, not an autonomous decision-maker



Chapter: Embedded Systems in Metabolic Bariatric Surgery – From Telemonitoring to Deep Learning applications in Embedded Systems for Biomedical Applications, Taylor & Francis 2025, eISBN 9781003508199, doi: 10.1201/9781003508199

The missing layer: from raw vitals to physiologic complexity

1

Raw vitals

WHAT CREWS CAPTURES TODAY

Heart rate, respiratory rate → single numbers, single thresholds (e.g., HR > 110 bpm)

→

2

Complexity features

WHAT IS MOSTLY STILL MISSING

Sample entropy, Poincaré geometry, detrended fluctuation analysis → how those numbers vary, moment to moment

→

3

Time-aware risk score

WHERE THIS NEEDS TO GO

A trajectory the model has seen diverge before → not a static cut-off, but a pattern of eroding resilience

CREWS answers "Is this patient deteriorating right now?"

Complexity-aware features aim to answer an earlier question: "Is this patient's physiologic resilience eroding, before deterioration is visible on a vitals chart?"

Variability is not noise — it may be the signal!

Obesity Surgery
https://doi.org/10.1007/s11695-026-08666-6

REVIEW

Complexity-Aware Artificial Intelligence in Metabolic Bariatric Surgery: Beyond Static Risk Prediction

Athanasios G Pantelis[1,2]

Received: 11 February 2026 / Revised: 19 March 2026 / Accepted: 4 April 2026

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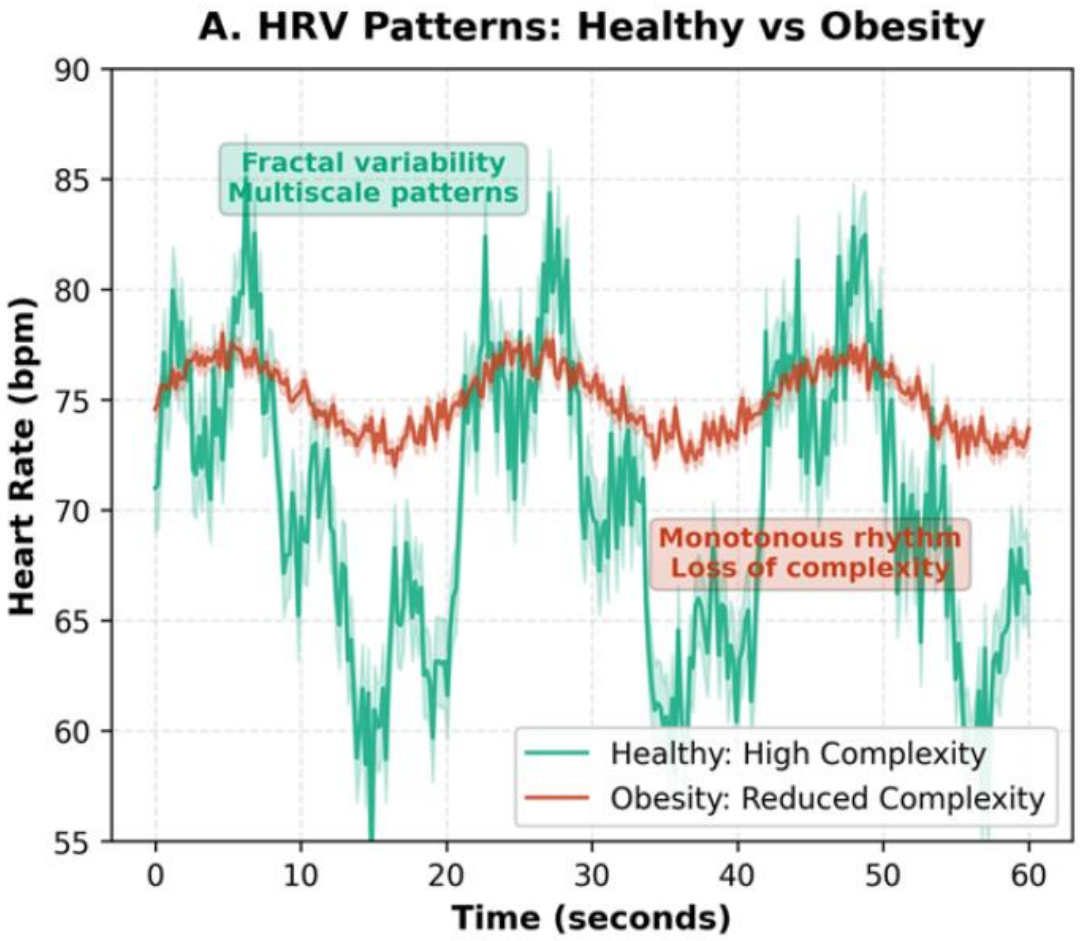

Pantelis AG, Obesity Surgery 2026; doi: 10.1007/s11695-026-08666-6

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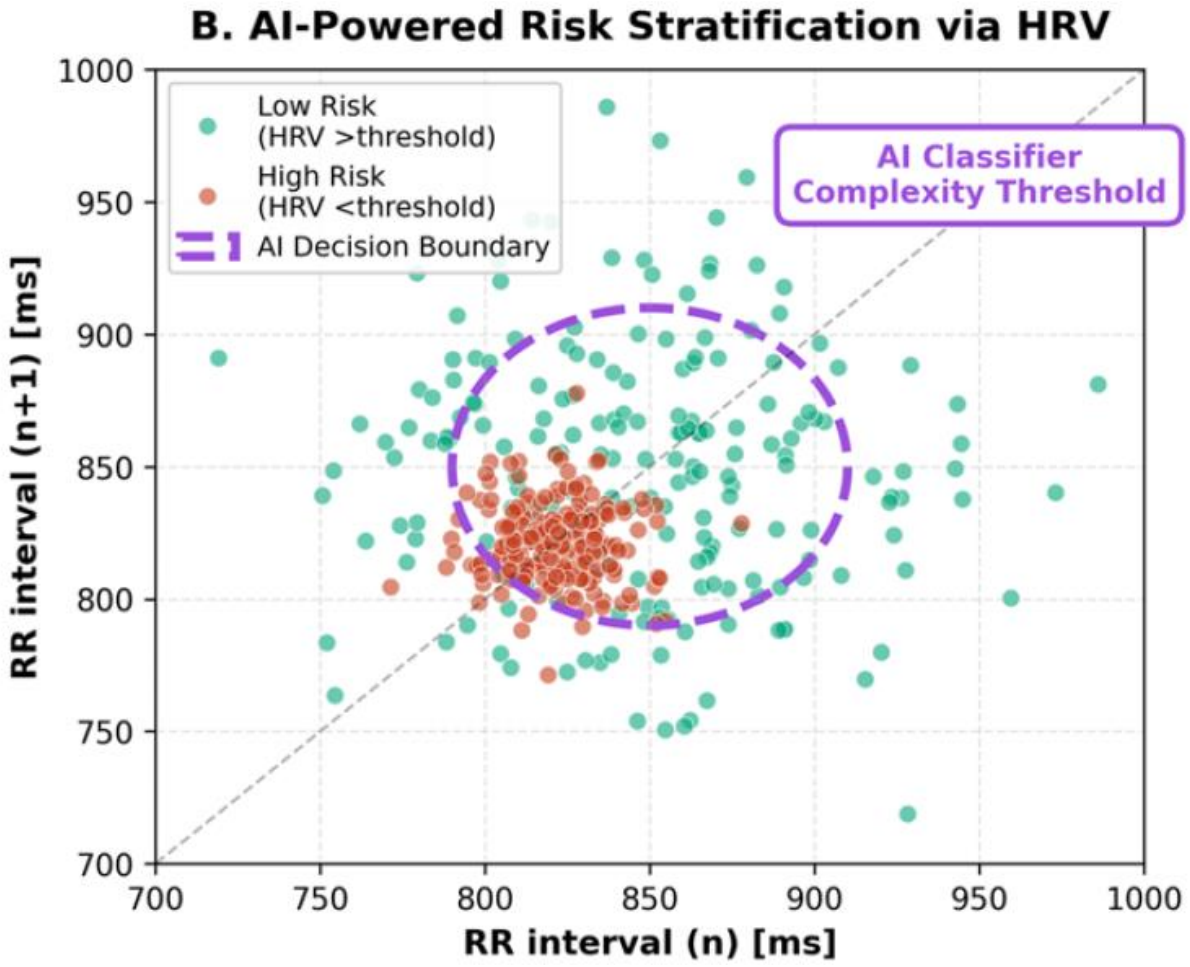

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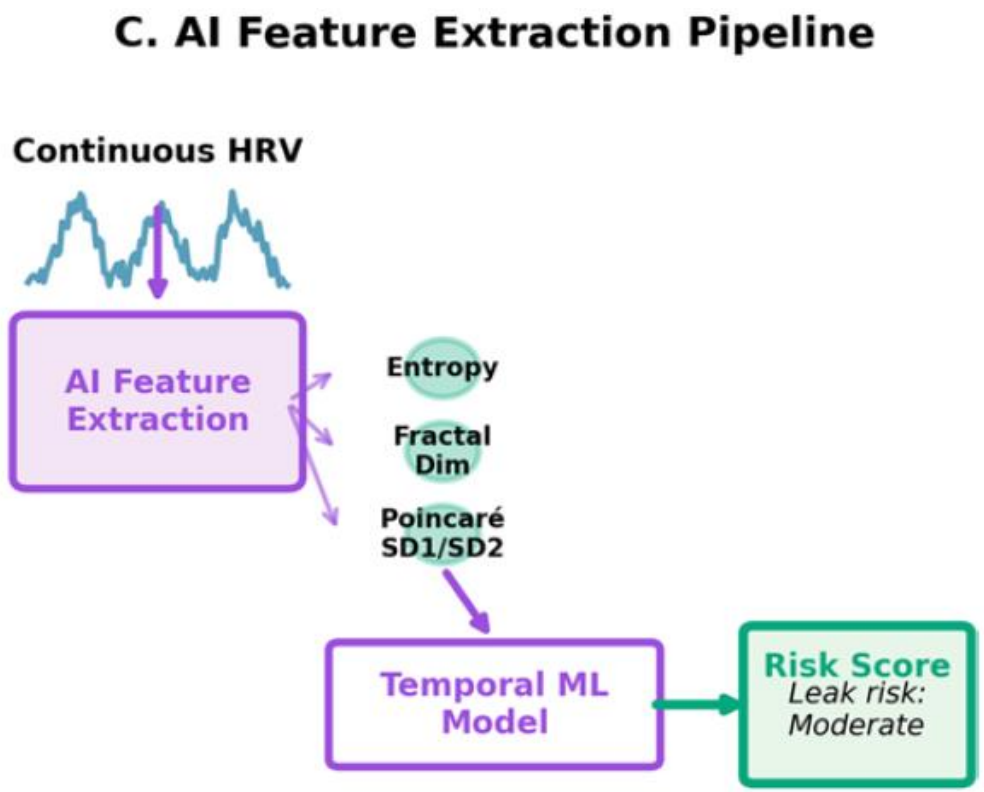

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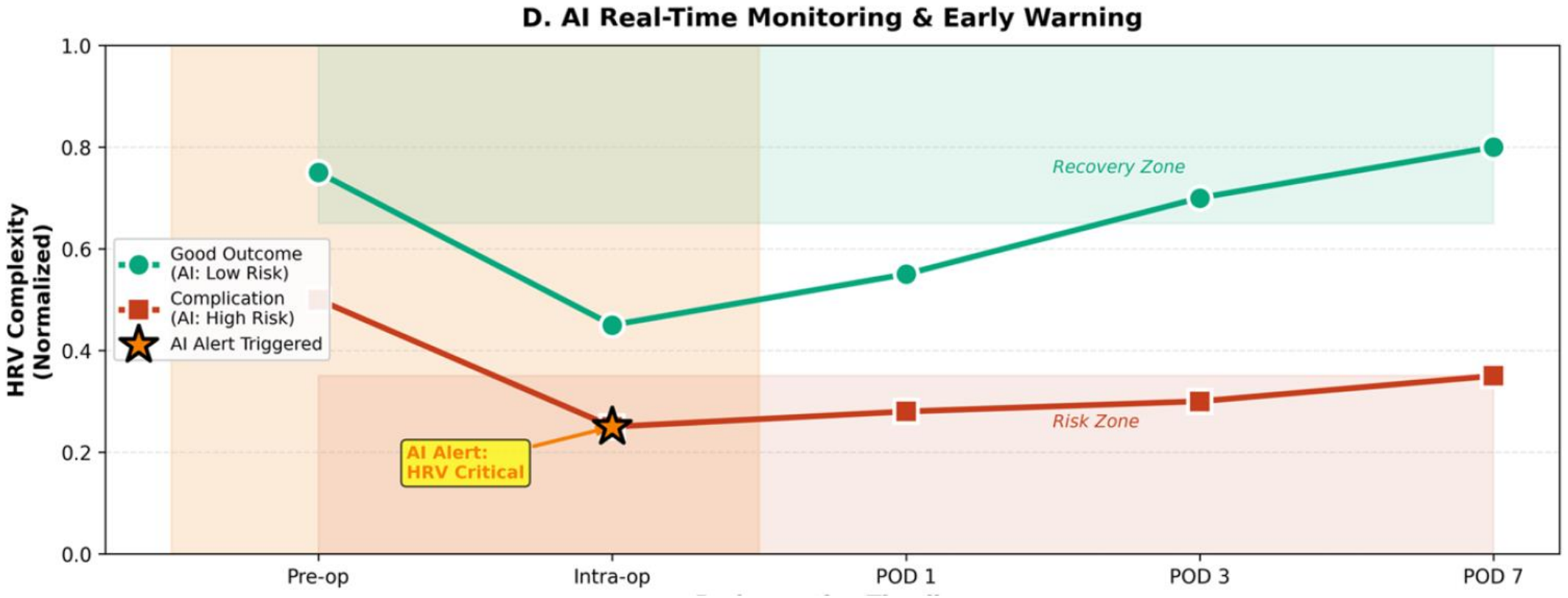

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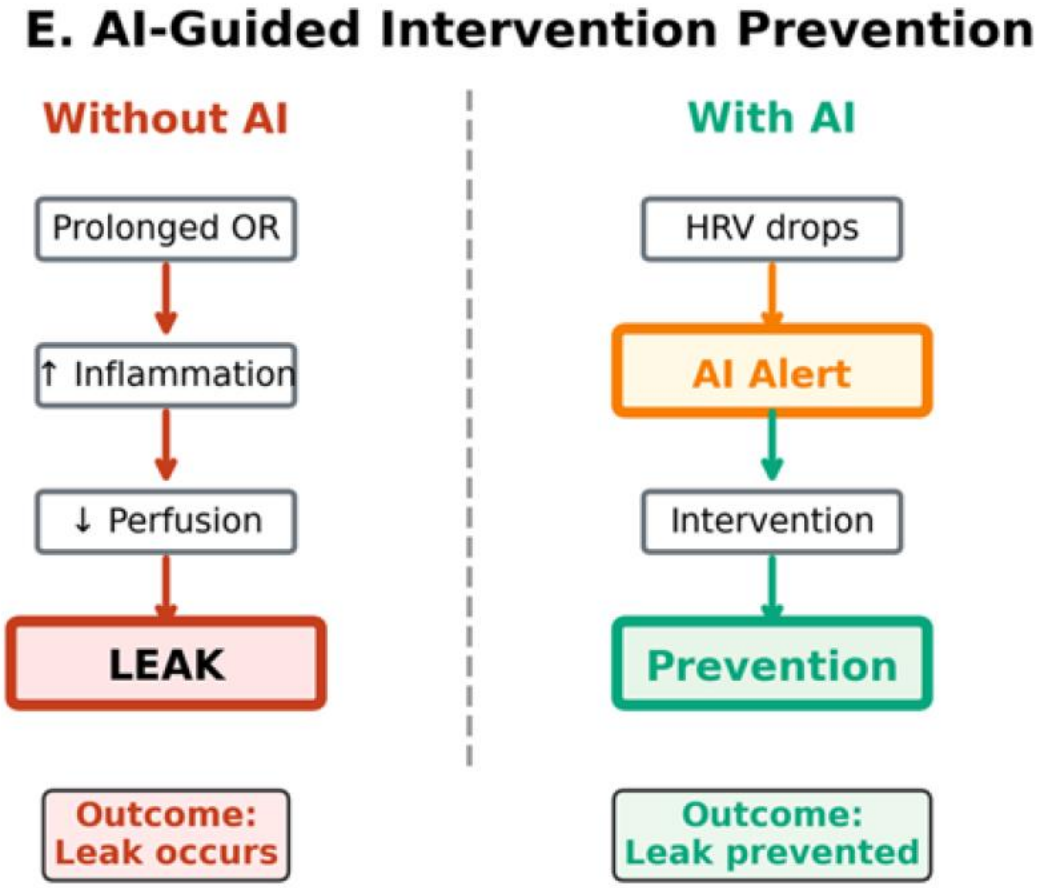


Pantelis AG, Obesity Surgery 2026; doi: 10.1007/s11695-026-08666-6

A complexity-aware AI framework for MBS

01

Signals

Continuous HRV, EEG, glucose, inflammatory markers, hemodynamic waveforms, intraoperative video

02

Features

Entropy, Poincaré geometry, detrended fluctuation analysis, critical-slowing-down indicators

03

Models

Temporal architectures — gradient boosting on rolling windows, temporal CNNs, attention-based transformers

04

Evaluation

Prospective temporal validation, calibration for rare events, bias audits, decision-curve analysis

***Interpretability is non-negotiable**: hybrid models that pair deep learning with transparent clinical logic build the trust needed for adoption.*

ACT III OF 3

The Path Forward

Held to the same evidentiary standard we just used to critique everyone else

What's actually in clinical use today — and what isn't

SOPHIA weight-trajectory tool

Deployed — but not complications

10 prospective cohorts + 2 RCTs (n=10,231); free clinician/patient app. It predicts 5-year weight trajectory after LSG, RYGB, and banding — a genuine deployment, but it says nothing about leak, VTE, or any postoperative complication.

ACS NSQIP Surgical Risk Calculator

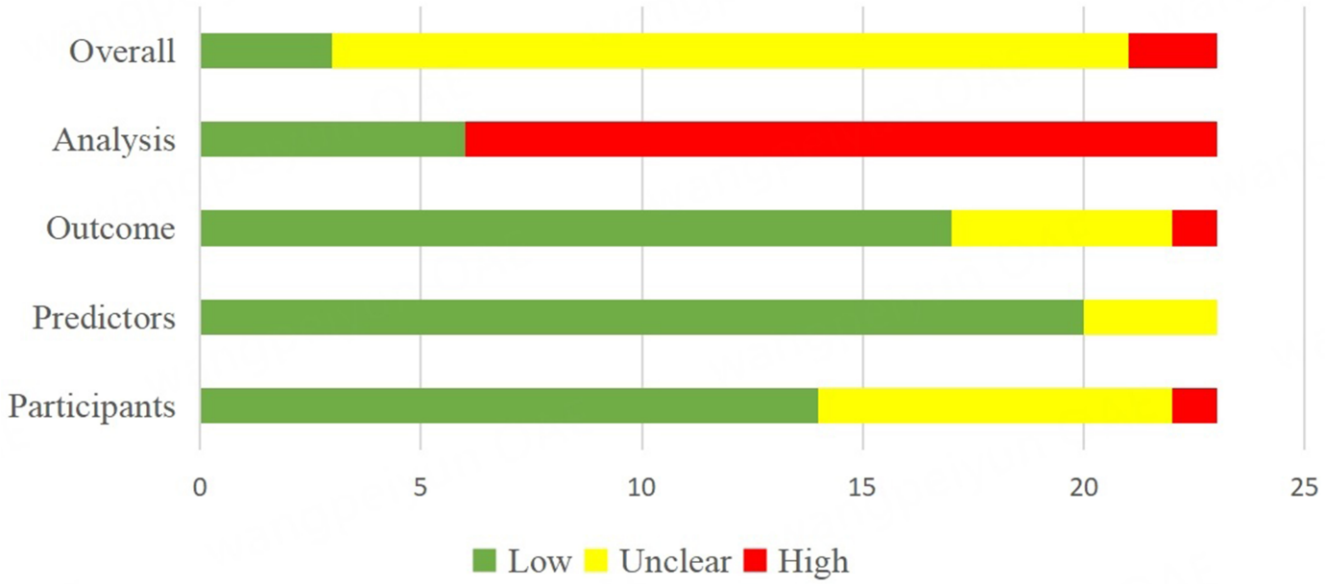
In daily use — not AI, not bariatric-specific

The complication-risk tool surgeons actually use for informed consent. Built on traditional logistic regression against 1.4M+ NSQIP patients across 1,557 CPT codes (Bilimoria et al. 2013) — general surgery, U.S. registry data, no bariatric-specific tuning.

No AI-driven, bariatric-specific complication model has reached clinically meaningful application

Saux et al., Lancet Digit Health 2023 (SOPHIA); Bilimoria et al., J Am Coll Surg 2013 (ACS NSQIP SRC)

Rigor is the bottleneck, not ambition



Siloed, discarded data

Anesthesia records, wearable streams, and video are captured but rarely integrated or retained beyond summary statistics.

No external validation

Most of the 23 reviewed studies never tested their model outside the training institution or registry.

Imbalanced, rare events

Leak and VTE occur in under 1% of cases; oversampling helps but risks inflating apparent performance.

Black-box interpretability

Deep learning gains accuracy but loses the transparency clinicians need to trust and act on a prediction.

The complexity-aware framework is not exempt from prospective, external validation

Pantelis et al., Art Intel Surg 2025;5:322-344

Four concrete next steps

01 Integrate existing data streams

Anesthesia monitors, surgical video, and postoperative telemetry already exist → connect them via existing health-IT standards instead of discarding them after summary extraction.

02 Build shared, temporal datasets

A collaborative, MBSAQIP/SOReg-anchored repository with continuous monitoring data and longitudinal outcomes → IFSO is well placed to coordinate this.

03 Test specific, falsifiable hypotheses

Can preoperative HRV stratify VTE prophylaxis? Does EEG-guided anesthetic depth cut delirium?
These are testable now, with existing technology.

04 Align regulatory & reimbursement pathways

FDA draft guidance on adaptive AI is a foundation; payers should recognize that preventing one leak (>$100,000) justifies investment in monitoring infrastructure.

TAKE-HOME MESSAGES

Three things to remember

01 Static models have plateaued

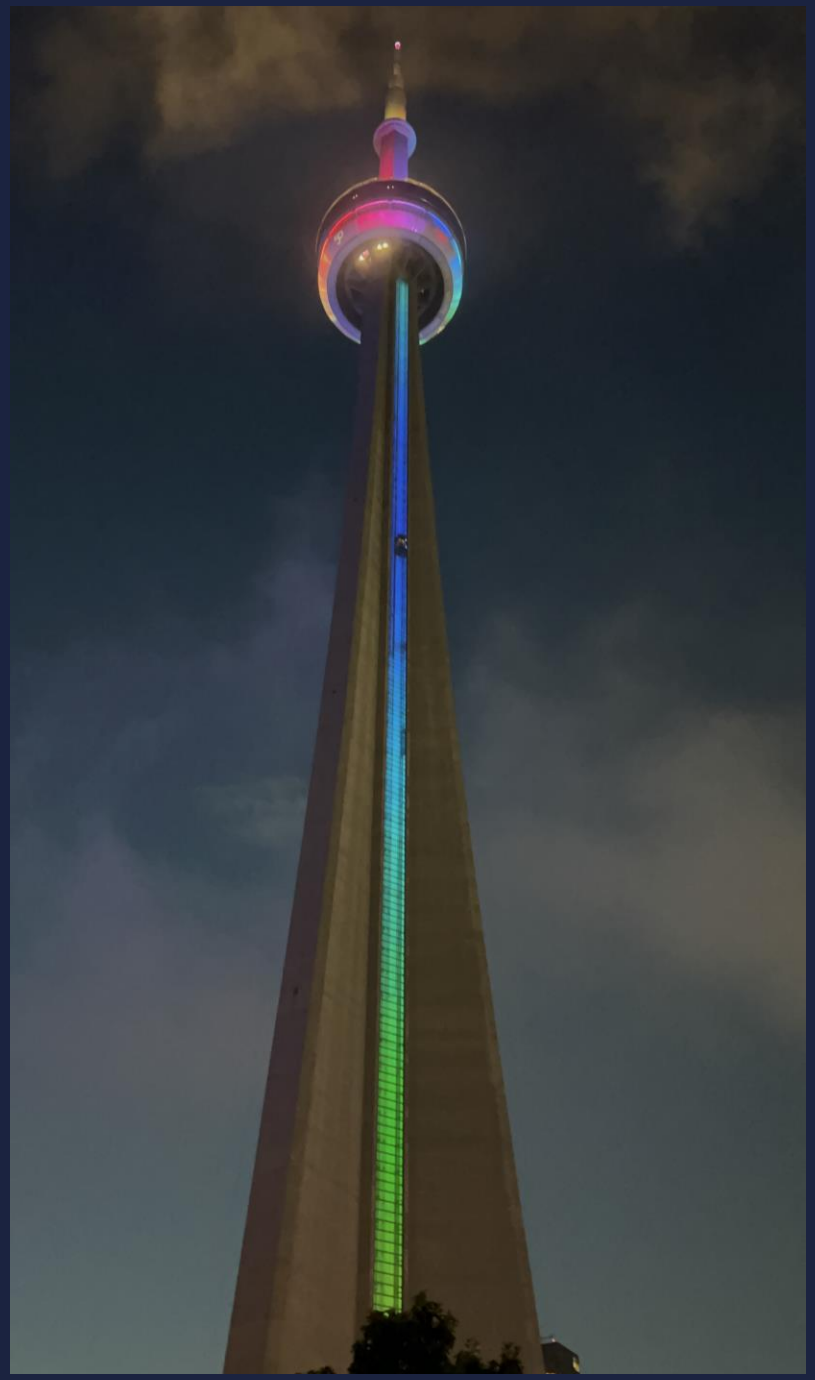
Both traditional calculators and first-generation AI treat patients as fixed points.

02 Variability is prognostic, not noise

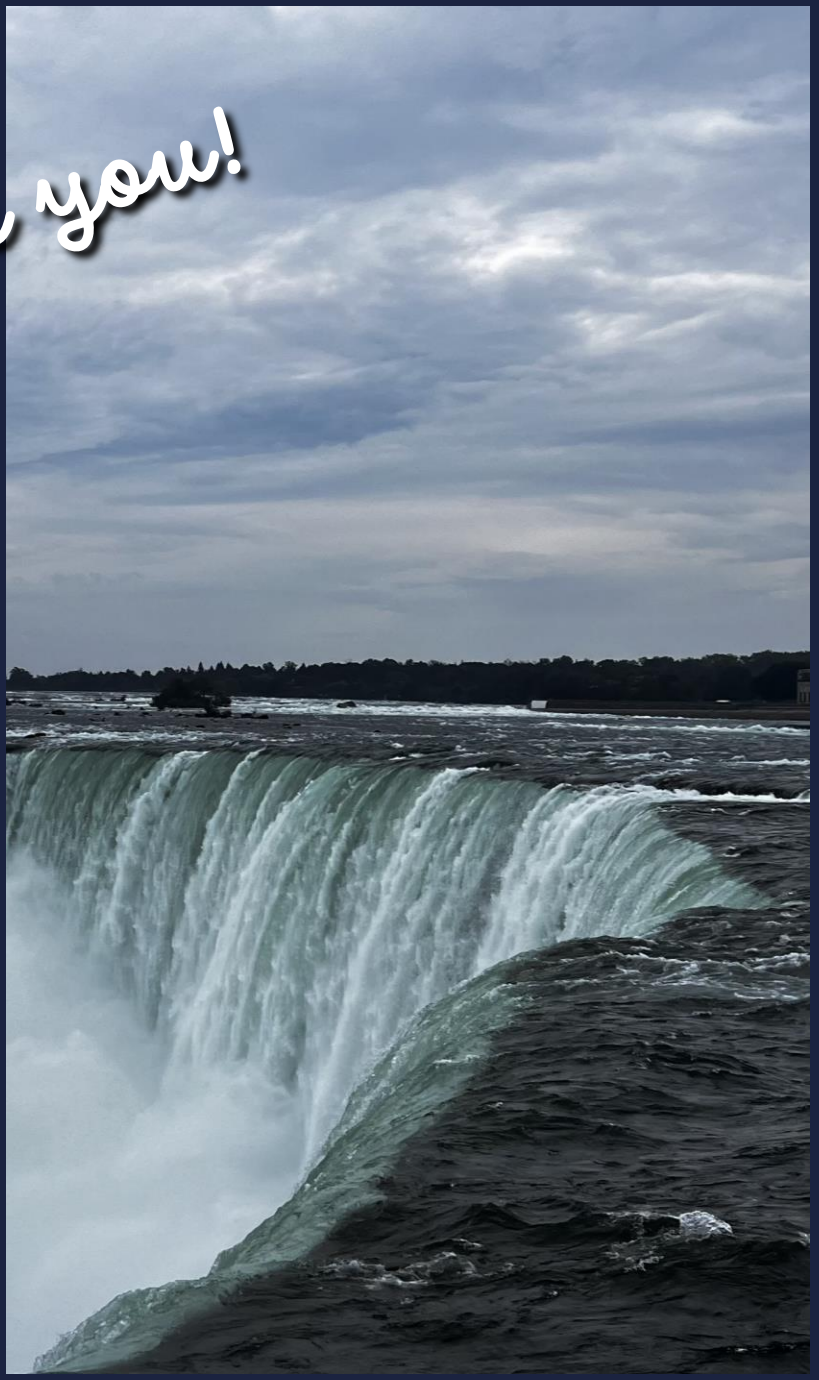
HRV, EEG, glycemic complexity… carry signal about physiologic resilience — and MBS is an ideal model to study this.

03 The infrastructure exists — integration doesn't

Continuous monitoring data is already generated in our ORs & wards. The next leap is connecting it, validating it prospectively, and trusting it.



Athanasios G. Pantelis
ath.pantelis@gmail.com
ORCID iD: 0000-0002-1788-2826



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