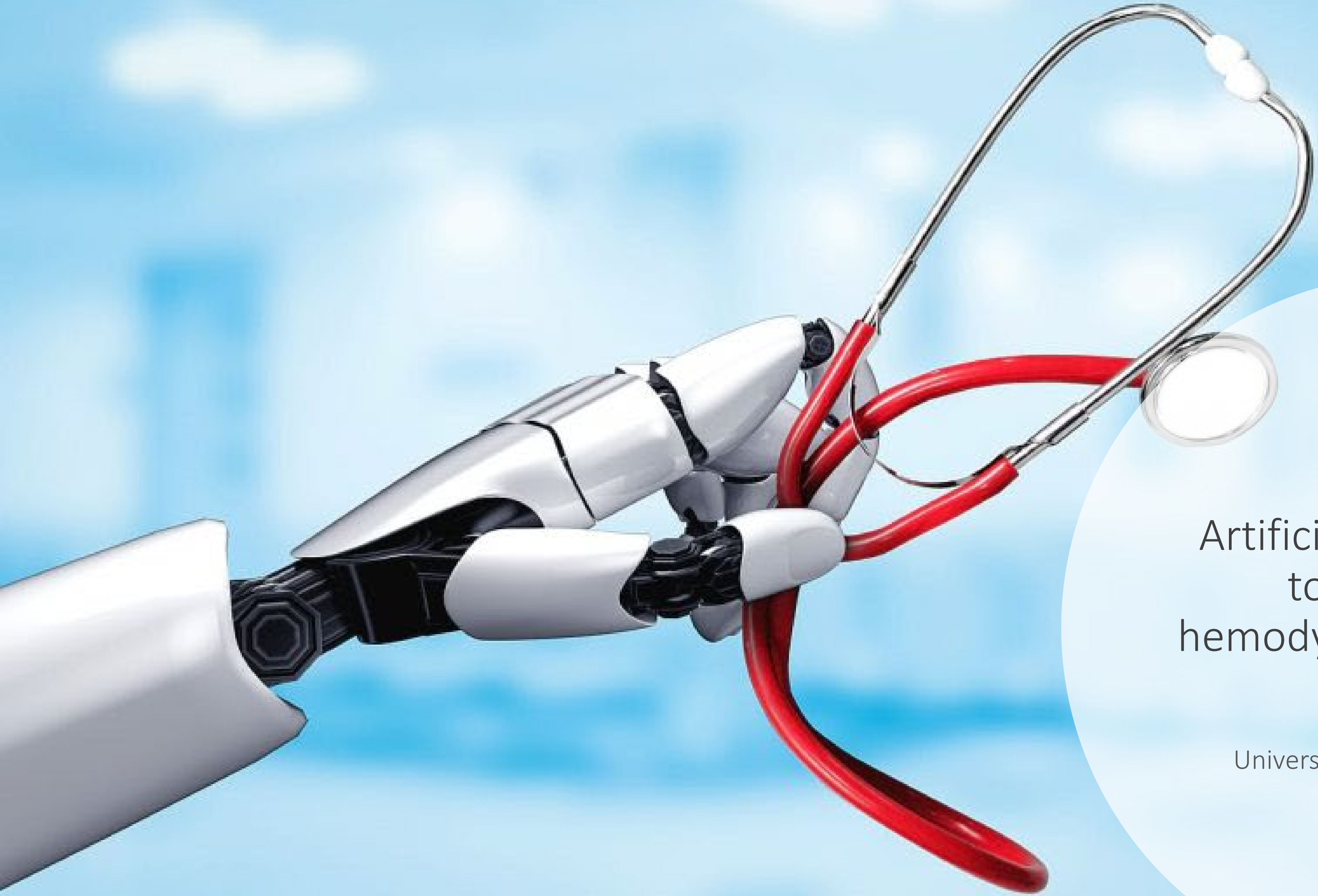


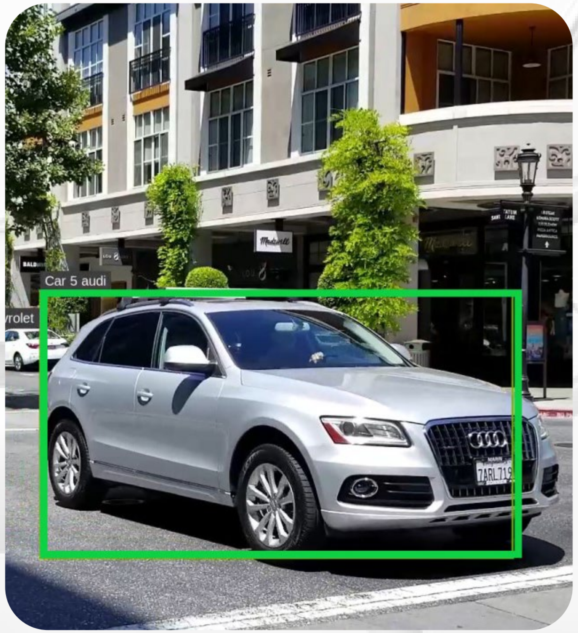
Artificial intelligence to improve hemodynamic stability

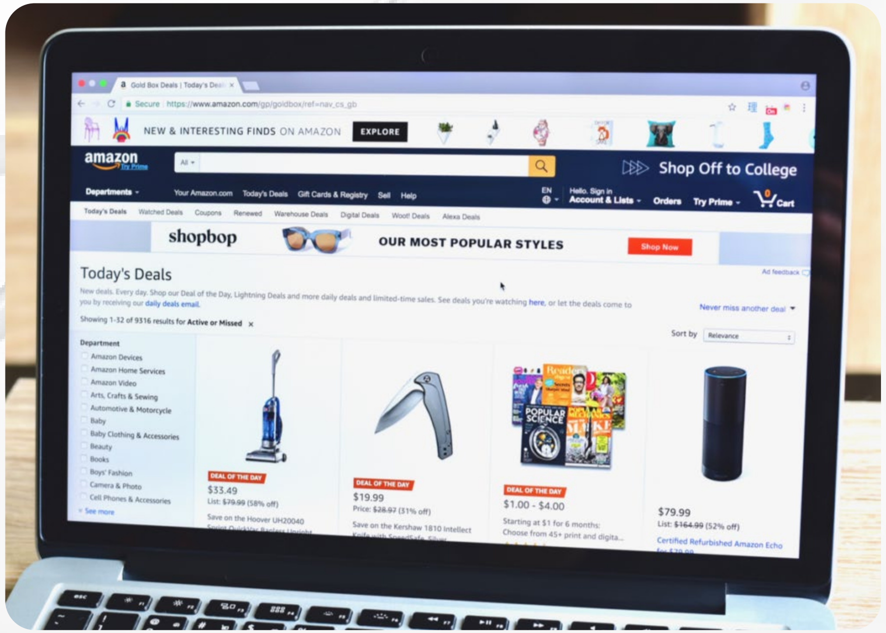
Jakub Kletecka
University Hospital in Plzen, CZ

Conflict of interest

- Our dpt. has a long-term cooperation with Edwards Lifesciences, Inc.
- Part of devices used in the presented study was sponsored
- Lecture fees from EW

What is artificial intelligence?





What is artificia

OpenAI

J Please write a short scientific article about perioperative hypotension. Use three citations.

Perioperative hypotension, defined as a systolic blood pressure of less than 90 mmHg or a decrease in systolic blood pressure of more than 20% from baseline, is a common complication in surgical patients. It can lead to decreased perfusion of vital organs, increased risk of complications, and prolonged recovery time.

Several factors can contribute to the development of perioperative hypotension, including anesthesia, blood loss, and the patient's underlying medical conditions. Anesthesia, particularly the use of neuromuscular blocking agents, can lead to decreased sympathetic tone and vasodilation, resulting in hypotension. Blood loss, either from surgery or from preoperative conditions such as anemia, can also contribute to decreased blood pressure.

Patients at high risk for perioperative hypotension include those with hypertension, heart failure, and other cardiovascular diseases. Additionally, older patients and those with a history of hypotension are at increased risk.

Effective management of perioperative hypotension includes identifying and addressing underlying causes, such as blood loss or anemia. Intravenous fluids, including crystalloids and colloids, can be used to increase blood volume and improve blood pressure. In some cases, vasopressors may be necessary to increase blood pressure and perfusion to vital organs.

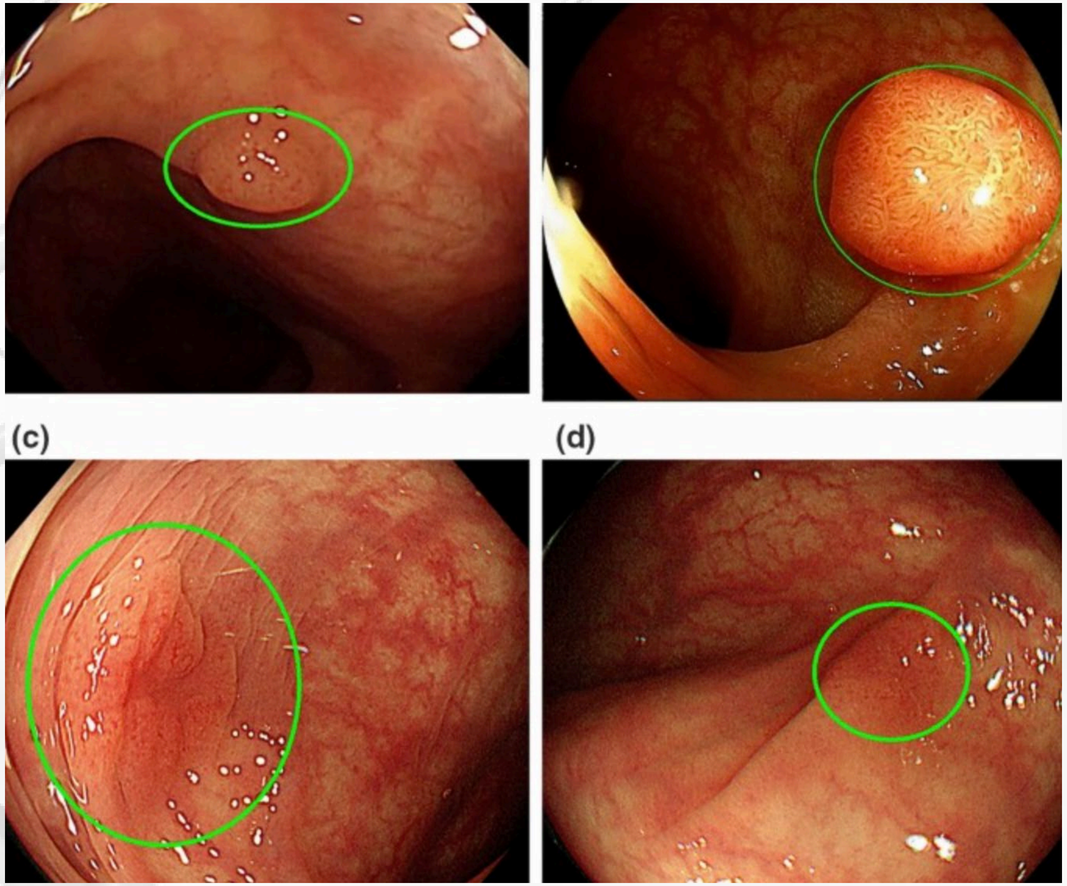
It is important for anesthesia providers to closely monitor blood pressure during the perioperative period and take prompt action to treat any instances of hypotension. Collaboration between anesthesia providers and surgeons can also help to minimize blood loss and manage other factors that may contribute to hypotension.

References:

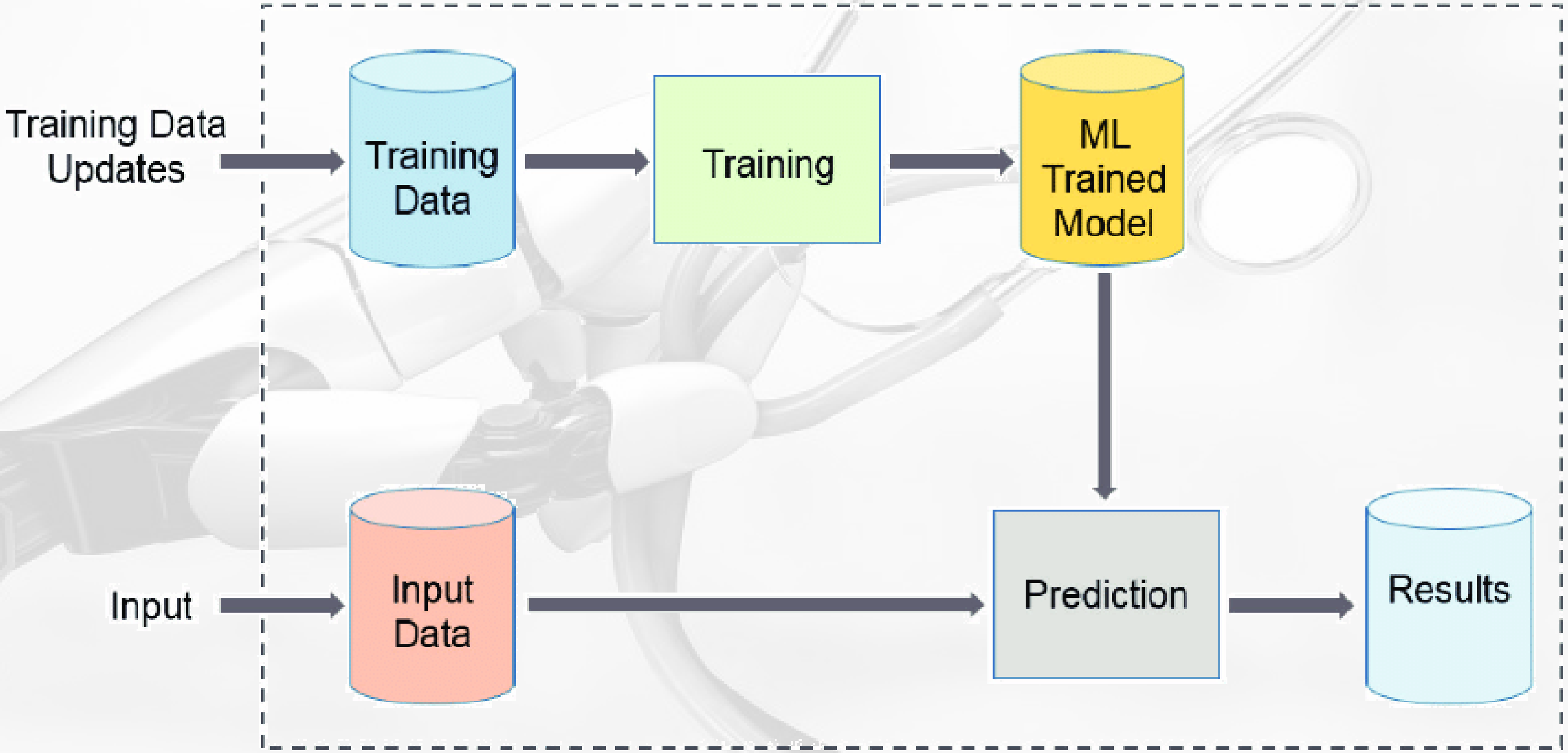
1. "Perioperative Hypotension" by D.L. Reich, D.J. Sessler, in Anesthesia and Analgesia, vol. 109, no. 1, pp. 185–197, 2009.
2. "Perioperative Hypotension" by J.F. Leslie, J.E. Sessler, in Anesthesia and Analgesia, vol. 117, no. 2, pp. 524–534, 2013
3. "Perioperative Hypotension: Pathogenesis, Identification and Management" by M.A. Memtsoudis, D.J. Sessler in Best Practice & Research Clinical Anaesthesiology, vol. 27, no. 1, pp. 119-131, 2013.

AI in medicine

- Radiology
- Endoscopy
- Pathology
- Disease pattern recognition
- Clinical decision support
- Medical records analysis

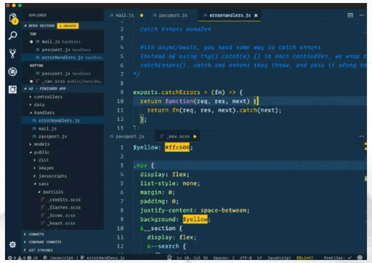


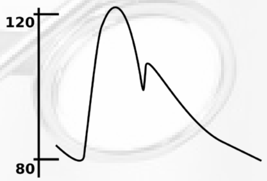
Machine learning (over)simplified…



10.5772/intechopen.84629

Predicting hypotension





data

analysis

model training and tuning

algorithm

pt. data

prediction

Hypotension prediction index (HPI)

Machine-learning Algorithm to Predict Hypotension Based on High-fidelity Arterial Pressure Waveform Analysis

Feras Hatib, Ph.D., Zhongping Jian, Ph.D., Sai Buddi, Ph.D., Christine Lee, M.S., Jos Settels, M.S., Karen Sibert, M.D., F.A.S.A., Joseph Rinehart, M.D., Maxime Cannesson, M.D., Ph.D.

ABSTRACT

Background: With appropriate algorithms, computers can learn to detect patterns and associations in large data sets. The authors' goal was to apply machine learning to arterial pressure waveforms and create an algorithm to predict hypotension. The algorithm detects early alteration in waveforms that can herald the weakening of cardiovascular compensatory mechanisms affecting preload, afterload, and contractility.

Methods: The algorithm was developed with two different data sources: (1) a retrospective cohort, used for training, consisting of 1,334 patients' records with 545,959 min of arterial waveform recording and 25,461 episodes of hypotension; and (2) a prospective, local hospital cohort used for external validation, consisting of 204 patients' records with 33,236 min of arterial waveform recording and 1,923 episodes of hypotension. The algorithm relates a large set of features calculated from the high-fidelity arterial pressure waveform to the prediction of an upcoming hypotensive event (mean arterial pressure < 65 mmHg). Receiver-operating characteristic curve analysis evaluated the algorithm's success in predicting hypotension, defined as mean arterial pressure less than 65 mmHg.

Results: Using 3,022 individual features per cardiac cycle, the algorithm predicted arterial hypotension with a sensitivity and specificity of 88% (85 to 90%) and 87% (85 to 90%) 15 min before a hypotensive event (area under the curve, 0.95 [0.94 to 0.95]); 89% (87 to 91%) and 90% (87 to 92%) 10 min before (area under the curve, 0.95 [0.95 to 0.96]); 92% (90 to 94%) and 92% (90 to 94%) 5 min before (area under the curve, 0.97 [0.97 to 0.98]).

Conclusions: The results demonstrate that a machine-learning algorithm can be trained, with large data sets of high-fidelity arterial waveforms, to predict hypotension in surgical patients' records. (ANESTHESIOLOGY 2018; 129:663-74)

PREDICTION of adverse events, from tornadoes to tsunamis, makes life-saving advance preparation possible. Yet in the operating room or the intensive care unit, clinicians often must manage the onset of arterial hypotension with essentially no warning. Hypotension during surgery, defined as mean arterial pressure (MAP) less than 65 mmHg,[1] is associated with increased rates of postoperative myocardial infarction[2] and acute kidney injury,[3] both predictors of poor long-term patient outcome.[4,5] In the intensive care unit setting, hypotension has been linked to an increased incidence of acute kidney injury.[6] The risk of serious complications increases with the duration of hypotension, but it can begin to develop within only a few minutes.[3] Advance warning that hypotension is imminent, even if the warning comes only 10 to 15 min ahead, could facilitate diagnostic and therapeutic measures to lessen the clinical impact.

Machine learning—a discipline within computer science used to analyze large data sets and develop predictive models—has evident applications to health care.[7–10] In the intensive care unit and operating room settings, physiologic waveforms represent a major source of information.[11,12]

Editor's Perspective

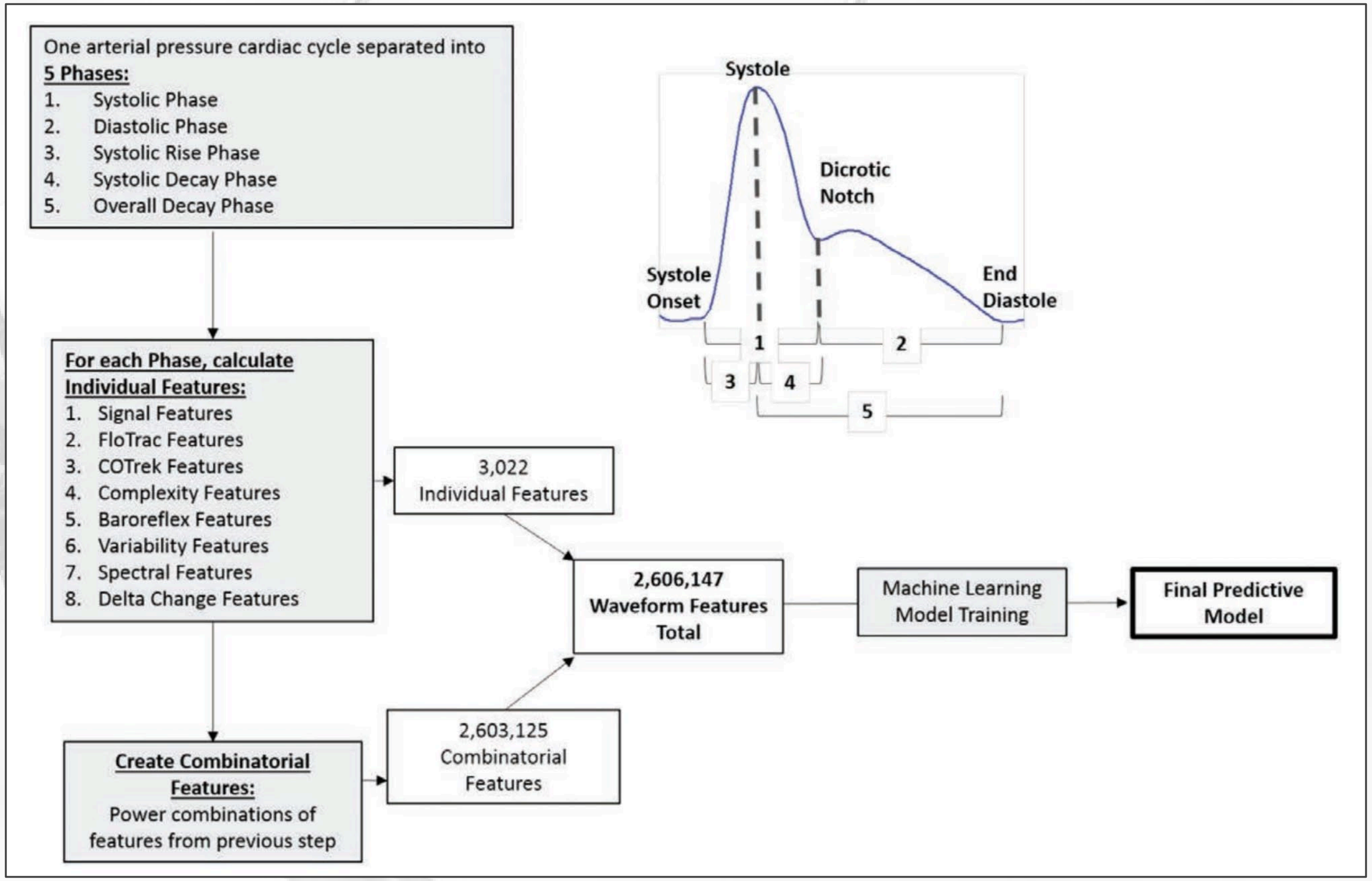
What We Already Know about This Topic

- The ability to predict intraoperative hypotension may advance the ability to prevent hypotension-associated complications effectively
- The extent to which advanced waveform analysis of invasive arterial lines may provide meaningful forewarning remains unknown

What This Article Tells Us That Is New

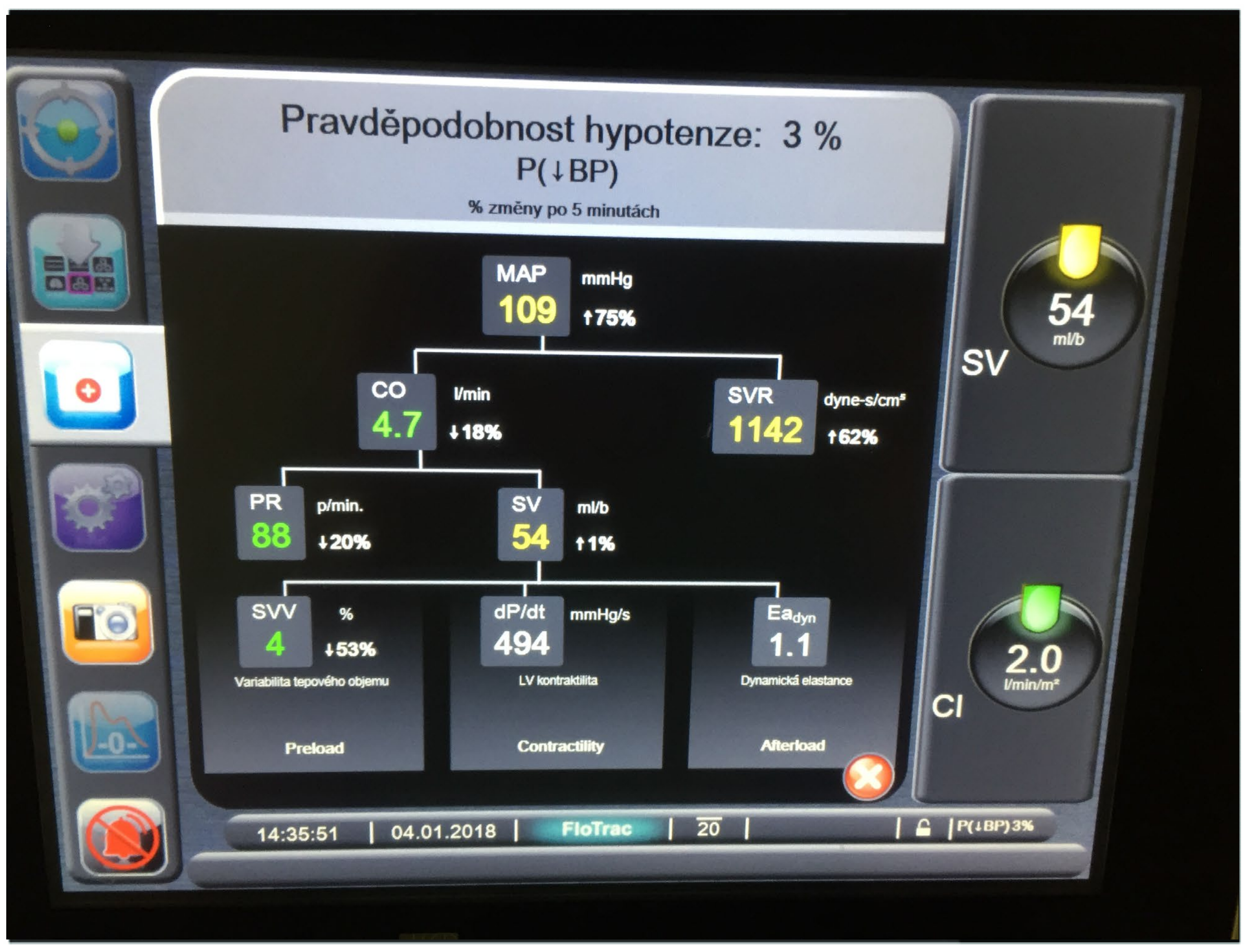
- A machine-learning algorithm based on thousands of arterial waveform features can identify an intraoperative hypotensive event 15 min before its occurrence with a sensitivity of 88% and specificity of 87%
- Further studies must evaluate the real-time value of such algorithms in a broader set of clinical conditions and patients

Typically, clinical monitors analyze physiologic waveforms to extract and display data that clinicians use to make decisions.[13,14] In 2009, an open challenge from PhysioNet and Computers in Cardiology prompted participants to develop tools to forecast acute hypotensive episodes, and



Anesthesiology. 2018 Oct;129(4):663-674.

Hypotension prediction index (HPI)



Probability of hypotensive episode in next 5 min.
(= MAP < 65 mmHg for more than 1 min.)

Dimensionless index (0-100),
calculated every 20 sec.

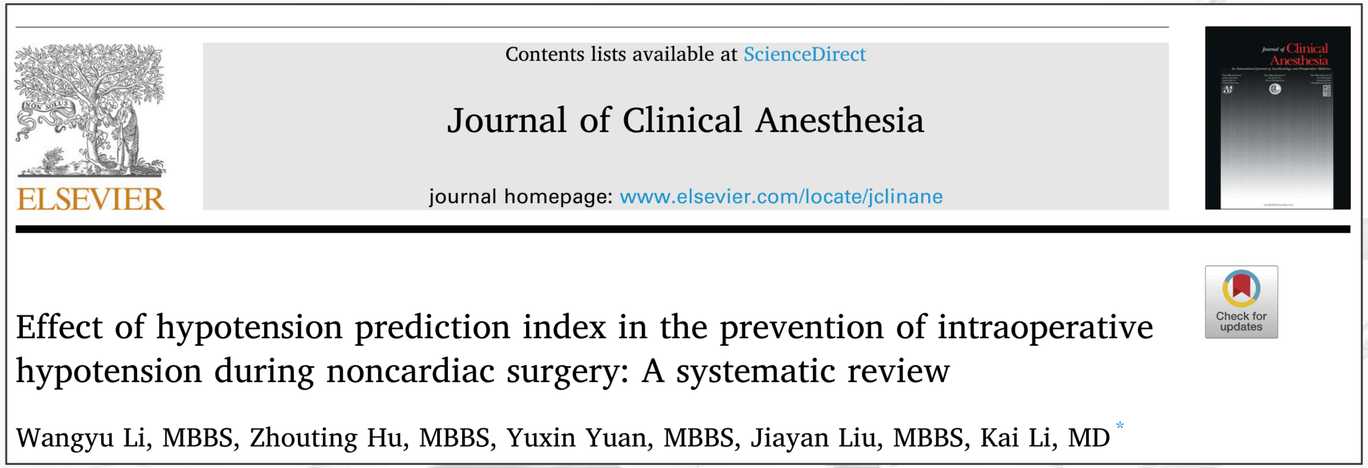
Value > 85 triggers alarm

Sensitivity 92% , specificity 92 %, AUC 0.97
(for 5 min. prediction)

Hypotension prediction index (HPI)

Change of the treatment paradigm

Does it work in clinical conditions?


Contents lists available at ScienceDirect

Journal of Clinical Anesthesia

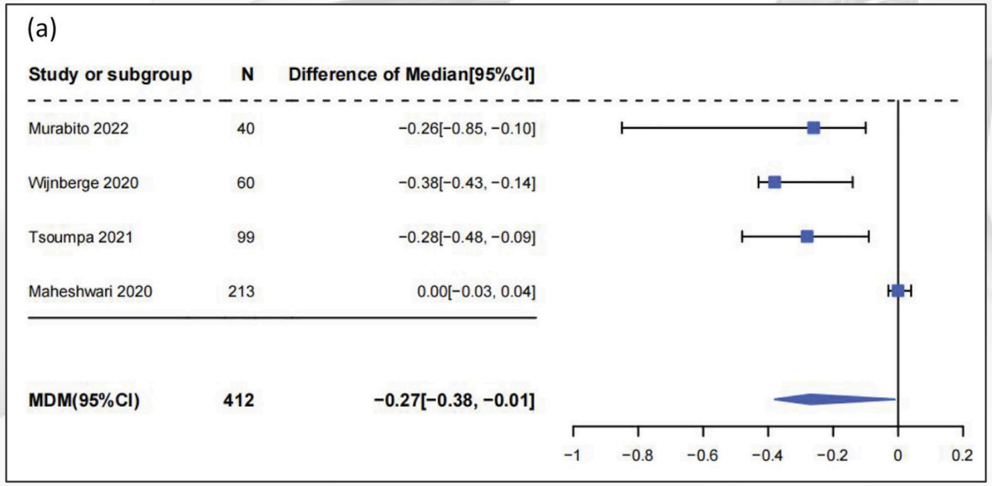
journal homepage: www.elsevier.com/locate/jclinane

ELSEVIER

Check for updates

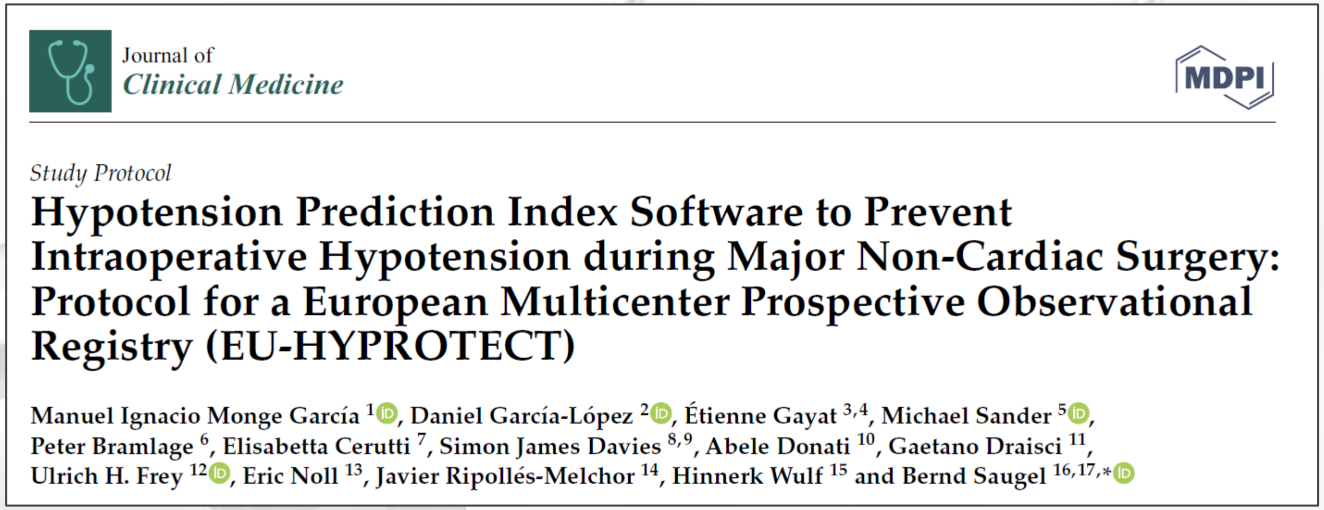
Effect of hypotension prediction index in the prevention of intraoperative hypotension during noncardiac surgery: A systematic review

Wangyu Li, MBBS, Zhouting Hu, MBBS, Yuxin Yuan, MBBS, Jiayan Liu, MBBS, Kai Li, MD *



„HPI has the potential to reduce the occurrence, duration, and severity of IOH during noncardiac surgery compared to standard intraoperative care.“

Does it influence outcome?


Journal of Clinical Medicine

MDPI

Study Protocol

Hypotension Prediction Index Software to Prevent Intraoperative Hypotension during Major Non-Cardiac Surgery: Protocol for a European Multicenter Prospective Observational Registry (EU-HYPROTECT)

Manuel Ignacio Monge García [1], Daniel García-López [2], Étienne Gayat [3,4], Michael Sander [5], Peter Bramlage [6], Elisabetta Cerutti [7], Simon James Davies [8,9], Abele Donati [10], Gaetano Draisci [11], Ulrich H. Frey [12], Eric Noll [13], Javier Ripollés-Melchor [14], Hinnerk Wulf [15] and Bernd Saugel [16,17,*]

…we are still not sure.

HPI study

Manuscript title: The Effect of a Hypotension probability indicator based protocol vs. Standard Care on Exposition to Intraoperative Hypotension During Elective Supratentorial Brain Surgery, a prospective single-center randomized pilot trial

Running title: Hypotension probability indicator in neurosurgery

Authors: Jiri POUSKA (M.D. Ph.D.),[1,2] Jakub KLETECKA (M.D. Ph.D.),[1,2] Jan ZATLOUKAL (M.D. Ph.D.),[1,2] Vaclav CERVENY (M.D.),[1] and Jan BENES (Prof. M.D. Ph.D.)[1,2,3*]

Under review

HPI study

„Does HPI use reduce „amount“ of hypotension during neurosurgery?“

„Does it influence clinical outcome?“

Setting

Pilot study – 40 pts., 20 HPI guided hemodynamic optimalization vs. SOC

Randomization, blinding

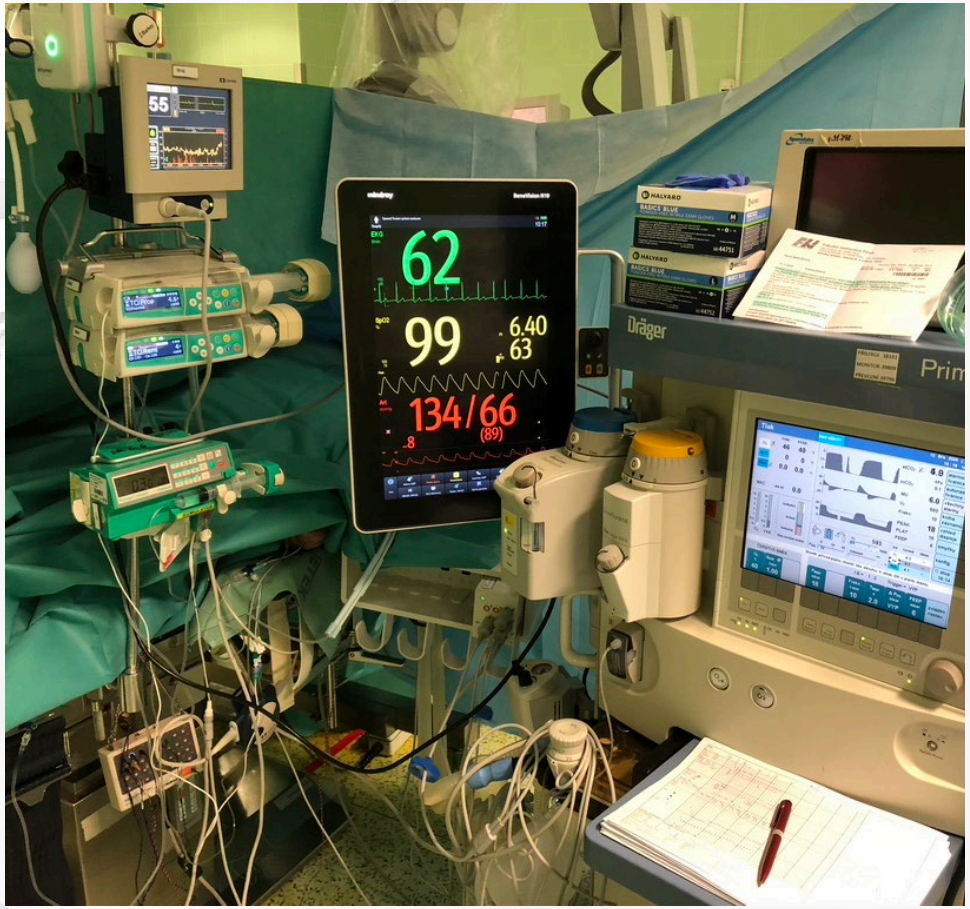
Adult ASA 1-3 pts. scheduled for **supratentorial tumour surgery**

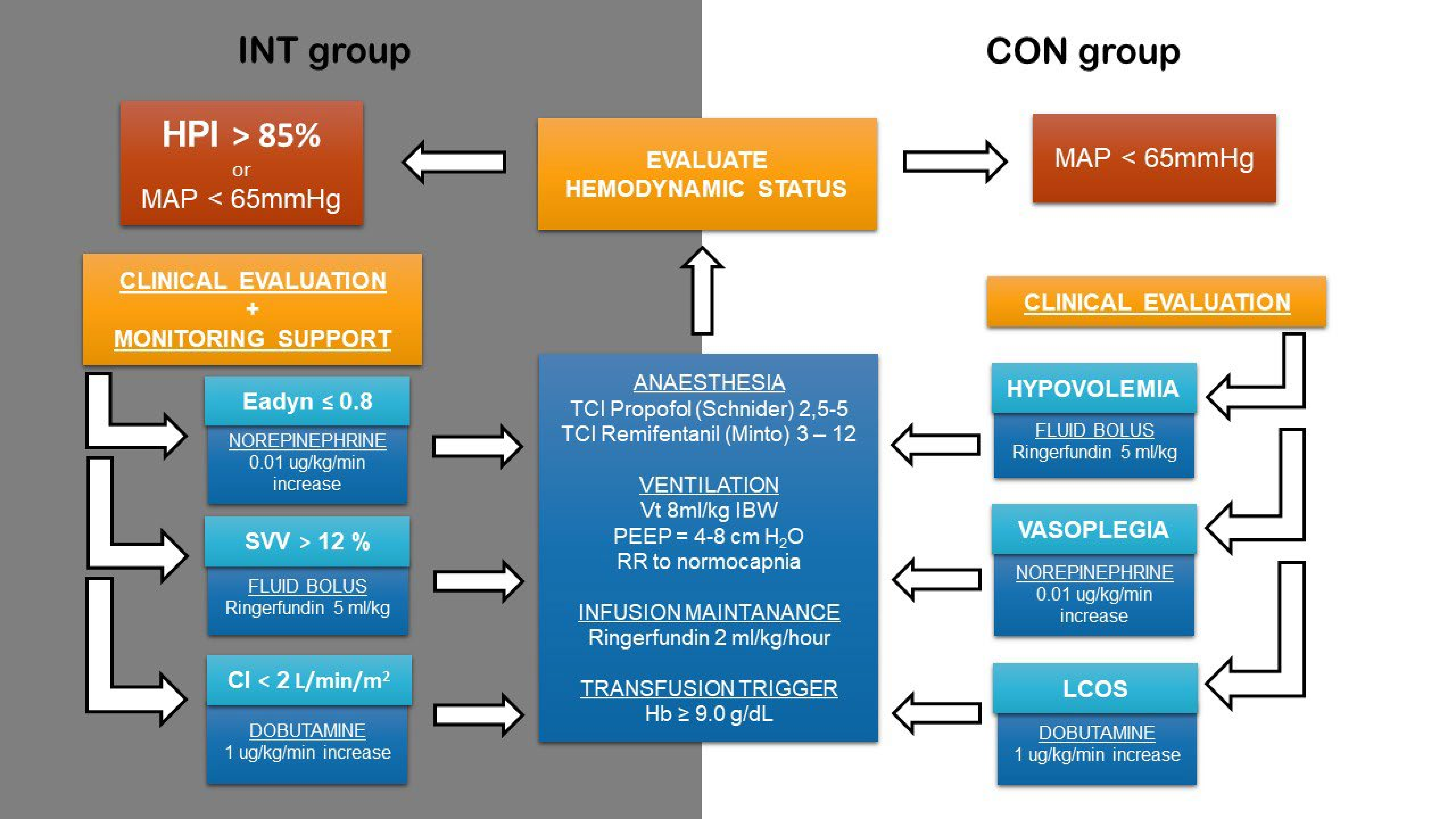
2018-2020

Sitting position and awake surgery excluded

Anesthesia protocol

- TIVA – propofol C_e 2.5-5 μg/ml (Schnider)
- Remifentanil C_e 3-12 μg/ml (Minto)
- Rocuronium only for intubation
- 2 ml/kg/hr of balanced crystalloid
- VCV 8 ml/kg, RR to normal etCO2




INT group
CON group
HPI > 85%
or
MAP < 65mmHg
EVALUATE
HEMODYNAMIC STATUS
MAP < 65mmHg
CLINICAL EVALUATION
+
MONITORING SUPPORT
CLINICAL EVALUATION
Eadyn ≤ 0.8
NOREPINEPHRINE
0.01 ug/kg/min
increase
SVV > 12 %
FLUID BOLUS
Ringerfundin 5 ml/kg
CI < 2 L/min/m²
DOBUTAMINE
1 ug/kg/min increase
ANAESTHESIA
TCI Propofol (Schnider) 2,5-5
TCI Remifentanil (Minto) 3 – 12
VENTILATION
Vt 8ml/kg IBW
PEEP = 4-8 cm H₂O
RR to normocapnia
INFUSION MAINTANANCE
Ringerfundin 2 ml/kg/hour
TRANSFUSION TRIGGER
Hb ≥ 9.0 g/dL
HYPOVOLEMIA
FLUID BOLUS
Ringerfundin 5 ml/kg
VASOPLEGIA
NOREPINEPHRINE
0.01 ug/kg/min
increase
LCOS
DOBUTAMINE
1 ug/kg/min increase

Primary outcome – hypotension „amount“

1) Number of pts. with MAP < 65 mmHg
2) Number and length of hypotension periods
3) „Dose of hypotension“– AUC of all time/pressure drops
4) Time-weighted average (TWA) – AUC/length of surgery

Secondary outcomes

1) pH, lactate, Hb level
2) Cummulative doses of anesthetics, pressors, fluids
3) Complications (respiratory, cardiovascular, neurological, other)
4) LOS – ICU, hospital, 1year survival

Results

Less pts. with hypotension episode in HPI arm (10 vs. 16, $p=0.049$)

All other hypotension parameters were not different between groups

SVV above 12% threshold for longer time in the control group

Lower norepi dose in HPI group (2.9 vs. 6.1 µg/kg, $p=0.02$)

Amounts of all other drugs and fluids were similar

Results

No significant difference in lab parameters between groups

Identical rate of complications

1year mortality was same in both groups (25 %)

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Public Group a day ago

Group Admins

Home

Mission

The **Data Science** section's mission is to ***promote techniques and technology to improve outcomes by turning data into better care***.

It incorporates the former TAHI Project Group.

Its goals are to:

1. Provide **education** for clinicians interested in developing or appraising new technology.
2. Promote **research** into clinical applications of data-driven healthcare, encouraging translation of novel computing and artificial intelligence techniques.
3. Drive **data-sharing** across Europe in a legal, ethical and publicly-acceptable way.
4. Promote **standard setting** (e.g. for Electronic Medical Records) and benchmarking, as well as ensuring technology is aligned to the needs of patients and clinicians.
5. Create a **collaborative framework**, facilitating the collaboration of ICU professionals, data scientists, engineers, legal and ethical experts, as well as engaging industry partners for patient benefit.

The next Data Science section meeting will take place on Monday, 24 October 2022, from 12:30 to 13:30 (Room 361, Level 3 of the Palais des Congrès in Paris).

> Access DS resources

Board

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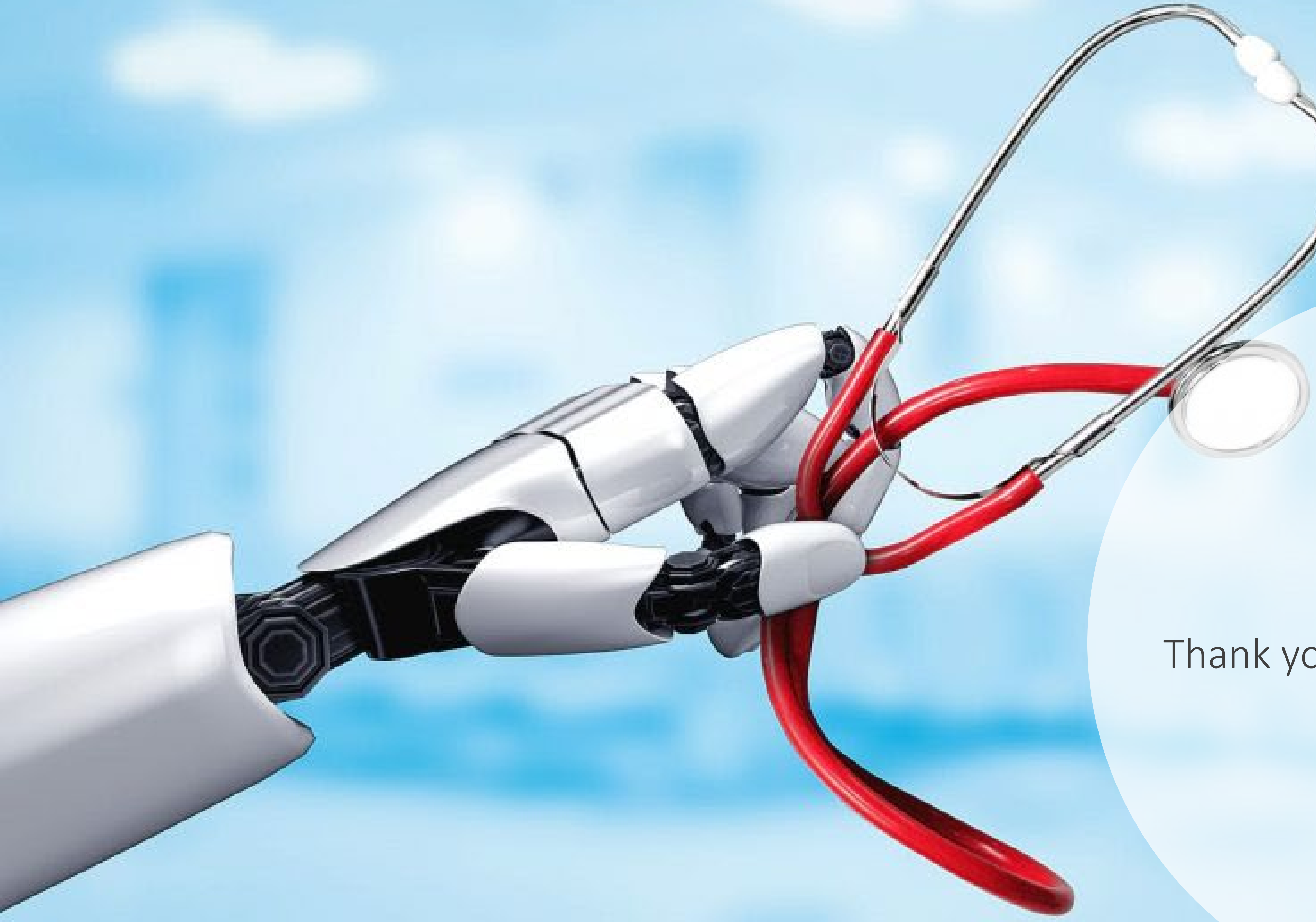
Chair	Ari	Ercole	Cambridge	United Kingdom
Deputy	Paul	Elbers	Amsterdam	The Netherlands



Thank you for your attention!

jakub@kletecka.cz