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DESIGN AND DEVELOPMENT OF AN APPLICATION TO PREDICT SUBARACHNOID BLOCK-INDUCED HYPOTENSION

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Abstract

Subarachnoid block (spinal anesthesia) is widely employed for lower limb and lower abdominal surgeries but is frequently complicated by hypotension, posing risks to patient safety and surgical outcomes. Predicting hypotension risk preoperatively is essential for tailored anesthesia management. We designed and developed a user-friendly application that integrates multiple clinical and radiological patient parameters—including age, body mass index, pre-existing hypertension, type of surgery, antihypertensive medication use, echocardiography findings, mean arterial pressure, perfusion index, inferior vena cava collapsibility, and autonomic dysfunction—to estimate individualized hypotension risk during spinal anesthesia. Major parameters receive double weighting in the risk calculation. The application features secure, password-protected data entry and storage, supporting clinical decision-making at the point of care. This tool can enhance anesthesiologists' ability to anticipate and manage hemodynamic changes, personalize perioperative care, and improve patient safety. Future developments aim to refine predictive accuracy, expand clinical integration, and adapt the application for broader anesthetic and surgical contexts.

INTRODUCTION

Subarachnoid block (spinal anesthesia) is a commonly used anesthetic technique for surgeries involving the lower limbs and lower abdomen. It offers effective anesthesia with a single injection but is frequently complicated by hypotension—a significant decrease in blood pressure that can lead to adverse perioperative outcomes if not anticipated and properly managed. The ability to predict which patients are at risk for hypotension during spinal anesthesia is critical for enhancing patient safety and optimizing anesthesia management.

In current anesthetic practice, various individual predictors of post–subarachnoid block hypotension have been studied, such as advanced age, increased body mass index, baseline hypotension, high sympathetic blockade levels, and reduced cardiac reserve demonstrated on echocardiography. Dynamic monitoring parameters like perfusion index (PI), pleth variability index (PVI), mean arterial pressure trends, and inferior vena cava collapsibility index (IVCCI) have also shown potential in anticipating hemodynamic instability. However, in routine clinical settings, interpreting these diverse parameters collectively in real time can be challenging, leading to either under-preparation or over-treatment. This gap highlights the value of a dedicated, integrated application capable of combining these variables into a single, weighted risk score, providing anesthesiologists with a fast, reliable, and evidence-based decision-making tool at the point of care.

Need for the Application

Despite the benefits of spinal anesthesia, the incidence of hypotension remains a critical concern, impacting patient safety and surgical outcomes. Current methods for predicting hypotension risk are often based on limited clinical judgment and may not comprehensively account for all relevant patient parameters. This underscores the need for a systematic and reliable predictive tool.

By developing an application that utilizes a comprehensive set of patient parameters (age, BMI, pre-existing hypertension, type of surgery, antihypertensive drug usage, ECHO, MAP, PPI, IVC collapsibility index, and autonomic dysfunction), we aim to fill this gap. This tool can provide anesthesiologists with a clear risk stratification, facilitating proactive measures to mitigate the risk of hypotension. The application's user-friendly design and secure features ensure practicality and data security in clinical settings.

Ultimately, this research aims to improve patient outcomes, enhance clinical decision-making, and streamline anesthesiologist workflows by providing a robust and accurate predictive tool for hypotension in patients undergoing spinal anesthesia.

Development of the Application

The application was designed to predict the likelihood of hypotension induced by subarachnoid block by incorporating a range of clinical and radiological patient parameters based on evidence from the literature and clinical expertise.

Key parameters included are:

- Age
- Body Mass Index (BMI)
- Pre-existing hypertension
- Type of surgery
- Use of antihypertensive medication
- Echocardiography (ECHO) findings
- Mean Arterial Pressure (MAP)
- Perfusion Index (PPI) derived from pulse oximetry
- Inferior Vena Cava (IVC) collapsibility index
- Presence of autonomic dysfunction

Parameters were classified into major and minor categories according to their relative influence on hypotension risk, with major parameters given double weight in the risk scoring system. The design focused on a secure, easy-to-use interface requiring password-protected login to ensure data confidentiality. Patient data entry fields were structured for clarity and efficiency, allowing rapid input and risk calculation at the point of care.

Scoring system
Minor parameters:

Parameter	**Score 2**	**Score 0**
Age	>55 years	<55 years
BMI	>30	<30
Preexisting hypertension	Yes	No
Type of surgery	Supra umbilical	Infraumbilical
Antihypertensive drugs	ACEI/ARB	No ACEI/ARB

Major parameters:

Parameter	Score 4	Score 2	Score 0
ECHO	Moderate LV dysfunction	Mild LV dysfunction	Normal LV functiom
MAP(mmHg)	60-79	80-99	>100
PPI	0-1	1-1.4	>1.4
IVC collapsibility index	>50%	20-49%	<20%
Autonomic dysfunction	Moderate	Mild	Nil

Risk is then stratified into three categories:

- Mild Risk (Score 0–10): Patients in this range are considered at low risk for hypotension following spinal anesthesia.
- Moderate Risk (Score 11–20): Patients are at an intermediate risk and may benefit from increased perioperative vigilance and preventive strategies.
- High Risk (Score >20): Patients scoring above 20 are at significant risk for hypotension and require proactive, individualized management.

Clinical Uses

The application serves as a valuable decision-support tool for anesthesiologists by providing an individualized risk assessment for hypotension during subarachnoid block (spinal anesthesia). By integrating multiple clinical and radiological parameters, it enhances the accuracy of predicting which patients are at elevated risk for experiencing hypotension, a common and potentially serious complication of spinal anesthesia.Clinical Uses:

- Preoperative Risk Stratification: The application allows clinicians to identify high-risk patients before surgery, enabling tailored anesthesia planning such as adjustment of fluid management and selection of appropriate vasopressors.
- Personalized Anesthetic Management: With the quantified risk score, anesthesiologists can customize perioperative monitoring intensity, choose prophylactic interventions, and modify anesthesia technique to mitigate hypotension.
- Improved Patient Safety: Early identification of patients likely to develop hypotension reduces the incidence of adverse events associated with inadequate blood pressure control, such as organ hypoperfusion or cardiovascular compromise.
- Enhanced Clinical Workflow: The app's user-friendly and secure design facilitates quick risk calculation at the point of care, supporting timely clinical decisions.
- Potential Integration with Clinical Systems: Future incorporation into electronic health records and anesthesia information systems can streamline data entry and enable real-time alerts, making risk prediction part of routine perioperative care.

Implications:

- The use of this application promotes evidence-based, personalized anesthesia care by translating multiple patient factors into a single actionable risk score.
- It supports proactive management strategies rather than reactive treatment following hypotension onset, potentially improving surgical outcomes and reducing morbidity.
- Broad clinical adoption of such tools may lead to standardization of hypotension risk assessment in spinal anesthesia, enhancing consistency and quality of care.

- The app's framework allows future expansion to include more parameters, adapt to other anesthetic techniques, and interface with hospital systems, thus evolving with clinical needs and technological advances.

CONCLUSION

The developed application offers a structured, evidence-based approach to predicting the risk of hypotension following subarachnoid block by integrating multiple clinical and radiological parameters into a single, easy-to-use scoring system. By classifying parameters as major or minor, assigning weighted points, and stratifying patients into mild, moderate, or high-risk categories, the tool enables anesthesiologists to anticipate hemodynamic instability and plan individualized anesthesia management well in advance.

Its secure, user-friendly interface allows rapid risk assessment at the point of care, supporting proactive interventions such as optimized fluid management, early vasopressor readiness, and enhanced intraoperative monitoring. The application bridges a critical gap in perioperative risk stratification, facilitating safer spinal anesthesia practice and improving patient outcomes.

Future enhancements, including broader clinical validation, integration into electronic health records, and expansion for use in other anesthetic and surgical contexts, have the potential to further increase its impact and adoption in routine anesthetic practice.

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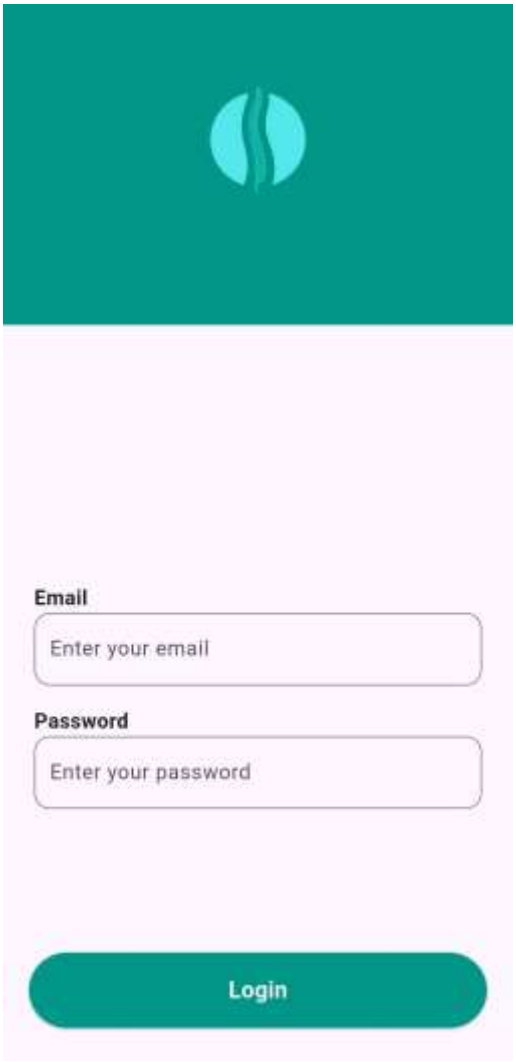
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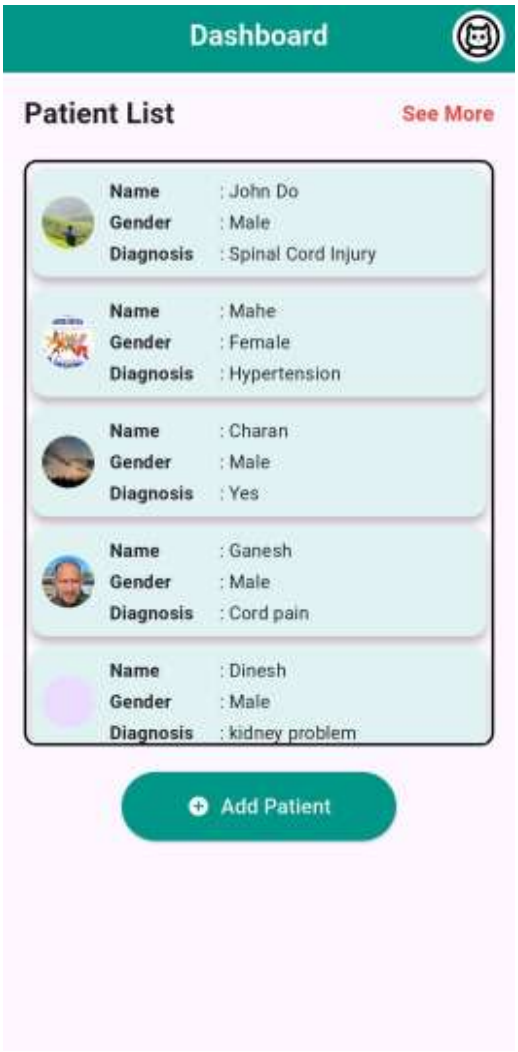
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Patient List
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Gender : Male
Diagnosis : Spinal Cord Injury
Name : Mahe
Gender : Female
Diagnosis : Hypertension
Name : Charan
Gender : Male
Diagnosis : Yes
Name : Ganesh
Gender : Male
Diagnosis : Cord pain
Name : Dinesh
Gender : Male
Diagnosis : kidney problem
Add Patient

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