Journal of Advances in Medicine and Medical Research

34(22): 185-196, 2022; Article no.JAMMR.91856
ISSN: 2456-8899
(Past name: British Journal of Medicine and Medical Research, Past ISSN: 2231-0614, NLM ID: 101570965)

Risk Factors for Hypotension after Anaesthesic Induction and Early Intraoperative Hypotension

Aziz Benakrout [a*], Abdellatif Chlouchi [a], Abdelhamid Jaafari [a], Mohamed Meziane [a], Nawfal Doghmi [a], Mustapha Bensghir [a] and Khalil Abouelalaa [b#]

[a] Department of Anesthesiology and Intensive Care, Faculty of Medicine and Pharmacy of Rabat, Military Hospital Mohammed V, Mohammed V University, Rabat, Morocco.
[b] Department of Anesthesiology and Intensive Care, Faculty of Medicine and Pharmacy of Rabat, Mohamed V Military Training Hospital, Morocco.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAMMR/2022/v34i2231592

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/91856

Original Research Article

Received 07 July 2022
Accepted 13 September 2022
Published 23 September 2022

ABSTRACT

Intraoperative hypotension should be differentiated with respect to the different underlying causal mechanisms. Post-induction hypotension is defined as arterial hypotension occurring during the first 20 minutes after induction of anaesthesia and early intraoperative hypotension is arterial hypotension during the first 30 minutes of surgery.
The aim of our study is to evaluate the incidence of intraoperative hypotension during surgery under general anaesthesia in a patient population and the factors influencing its occurrence.
Materials and Methods: This is a prospective study, carried out over a period of 4 months on 154 patients scheduled for surgery under general anaesthesia at the Military Hospital of Instruction Mohammed V in Rabat. We collected the following information : age, sex, ASA score, body mass index, comorbidities, drug intake and type of surgery. The occurrence or not of post induction hypotension and early intraoperative hypotension.
Results: The mean age of the patients in our case series was 58.5 ± 12 years. The sex ratio was 1.4 with a predominance of males. ASA I and II status were predominant. In univariate analysis: advanced age, the existence of chronic arterial hypertension and the decrease in systolic blood

[#] Head of Service of the Operating Theaters;
**Corresponding author: E-mail: azizbenakrout@gmail.com;*

pressure before induction were factors favouring the occurrence of intraoperative hypotension. In multivariate analysis: We found that these 3 factors were independently related to the occurrence of intraoperative hypotension.

Conclusion: We found that lower pre-induction systolic blood pressure, older age and comorbidity such as hypertension are factors independently associated with post-induction and early intraoperative hypotension. We believe that this will allow preventive optimisation of the risk through early implementation of continuous haemodynamic monitoring and adequate therapeutic intervention.

Keywords: Risk factors; post induction hypotension; early intraoperative hypotension.

1. INTRODUCTION

Each year, more than 300 million surgical procedures are performed worldwide [1]. Rates of major complications and mortality in the first weeks after surgery remain very high [2]. Postoperative deaths are a consequence of postoperative complications [3], which occur in up to a quarter of patients after hospital-based surgery. To avoid postoperative complications, it is crucial to identify and avoid modifiable risk factors for their occurrence. One modifiable risk factor for postoperative complications may be intraoperative hypotension (IOH). Despite enormous medical advances, intraoperative hypotension remains one of the most common adverse events in patients undergoing anaesthesia for surgical procedures. There is no universal definition of intraoperative hypotension [4]. The percentage range rather than the specified value defines intraoperative hypotension as clinically significant. Most researchers suggest that "normal ranges" of blood pressure are those values that do not differ by more than 30% from baseline. Some classifications of intraoperative hypotension include the intraoperative use of vasopressors [5]. Studies that have reported an association between IOH and adverse outcomes have used very different definitions of IOH. Some authors have defined IOH as a decrease in systolic blood pressure (SBP) or mean blood pressure (MBP) below a certain absolute threshold [6]. While others have used a decrease in blood pressure relative to the patients' baseline blood pressure [7]. Combinations of definitions including the duration of the decrease in blood pressure have also been used [8].

However, the incidence and causes of IOH could be affected by different factors depending on the phase of anaesthesia and surgery in which it occurs. It is therefore assumed that different phases of IOH should be defined due to different underlying causal mechanisms.

Thus, we define the entities:

1. Post induction hypotension (PIH) : arterial hypotension occurring during the first 20 minutes after induction of anaesthesia. As well as that which occurs between the induction of anaesthesia and the start of surgery".
2. Early intraoperative hypotension (EIH) : which is the arterial hypotension that occurs during the first 30 minutes of surgery.

1.1 Objectives

- The aim of our study is to determine the incidence of hypotension during general anaesthesia in our practice. Defined as a decrease in MBP of more than 30% compared to the first blood pressure measurement in the operating room. This definition is based on that of Bijker [9].
- To analyse the risk factors for the occurrence of hypotension after anaesthetic and early induction in a general population of patients scheduled for surgery under general anaesthesia.
- Finally, to attempt to review the literature on their impact and the elements of perioperative evaluation, which allow the optimization of the preparation of these patients for surgery and the prevention of preoperative hypotension.

2. MATERIALS AND METHODS

This is a prospective, cross-sectional, observational study that was carried out over a period of 4 months (from January 1, 2021 to May 1, 2021) in the Operating Room Department of the Mohammed V Military Teaching Hospital in Rabat, including 154 patients.

A patient informed consent form has been completed and kept in a register.

1. Inclusion criteria

- Age over 18 years.
- American Society of Anaesthesiologists (ASA) Class I-II-III physical status.
- Scheduled non-cardiac surgery with an estimated duration of more than 30 minutes.
- General anaesthesia, with intubation and mechanical ventilation.

2. Exclusion criteria

- Stay in intensive care unit.
- Patients who suffered from heart failure.
- Regional anaesthesia was performed before induction of anaesthesia.
- Emergency Surgery.
- Fast Sequence induction indication for full stomachs.

Patients are admitted to the operating room and transferred to the operating room. Standard monitoring was installed, a peripheral venous line was taken with an 18 or 20 G catheter and then IV infusion with 0.9% saline was started. The patients in our study did not receive any premedication. Pre-oxygenation was performed using a face mask. Anaesthesia was induced with Fentanyl (1 to 3 µg.kg -1), Propofol (1.5 to 2.5 mg. Kg-1) and Rocuronium (0.5 to 0.9 mg. Kg-1). Patients were intubated and mechanical ventilation was initiated with a tidal volume of (6 to 8 ml. Kg-1) at a positive exhalation pressure of 5 mbar. After induction, general anaesthesia was maintained with Propofol or Sevoflurane or inhaled Isoflurane. Drug doses for induction (Propofol) and neuromuscular blockade were left to the discretion of the anaesthetists present. The end point of the Propofol induction was the loss of response to verbal commands. After adequate relaxation was achieved, the airway was secured by direct laryngoscopy and orotracheal intubation. The choice of anaesthetic maintenance (volatile, intravenous) was not standardised and was entirely at the discretion of the anaesthetist. All subjects were monitored according to the recommendations of the learned societies. Vital signs heart rate (HR), mean arterial pressure (MAP) and pulse oxygen saturation (SpO2) were recorded just before induction and then every minute after induction for 10 minutes. Administration of an inhaled agent (aiming for a minimum alveolar concentration of 0.7 to 0.8 in an air-oxygen mixture (60 :40) was started. Hypotension after induction of anaesthesia was defined as a fall in MAP below 65 mmHg and/or a fall in MAP of more than 30% from baseline. Significant hypotension (MAP less than 55 mm Hg or a fall of more than 40% in MAP) or prolonged hypotension (duration greater than or equal to 2 min) was treated with intravenous ephedrine boluses. Significant bradycardia (HR <40 beats/min) was treated with intravenous atropine. We defined two distinct entities of arterial hypotension according to the period during which it occurred:

- From induction of general anaesthesia to 20 min post-induction, called Post Induction Hypotension (PIH).
- During the period from the start of surgery until 30 minutes from the start of the operation, known as early intraoperative Hypotension (EIH).

Intraoperative data were recorded in real time on a data sheet.

3. RESULTS

3.1 Epidemiological Data

3.1.1 Age of patients

The average age of the patients was 58.5 ± 12 years. With extremes ranging from 26 to 78 years.

3.1.2 Gender of patients

The sex ratio found was 1.40 (90 men to 64 women).

3.1.3 ASA status

In our case series, the division of patients into 3 groups according to ASA status: ASAI, ASAII, ASAIII.

There was a clear predominance of the ASA I and ASA II group with percentages of 48.1% and 41.5% respectively, in contrast to a low percentage of the ASA III group which corresponds to 10.4% (Table 1).

3.1.4 Co-morbidities

The comorbidities observed in our case series are mainly hypertension (27%) and diabetes (21%), while renal and respiratory pathologies are marked by minimal percentages (respectively 2.6%, 7.15%) (Table 2).

Table 1. The different ASA statuses in our study

ASA STATUS	Number	Percentage
ASA I	74	48,1 %
ASA II	64	41,5%
ASA III	16	10, 4%

**ASA: American Society of Anesthesiologists.*

Table 2. The different comorbidities found in our study

Pathologies	Number	Percentage
Diabetes	33	21,4%
Renal pathology	4	2,6%
Respiratory Pathology	11	7,15%
HBP	41	26,62%
Other	7	4 ,63%

**HBP: hight blood pressure*

3.1.5 Current anti-hypertensive treatment

Among the most commonly used cardiovascular treatments in patients with underlying cardiac disease, Enzyme conversion inhibitors and calcium inhibitors predominate. The others have minimal percentages (Table 3).

3.1.6 Body mass index (BMI)

We divided the 154 patients in our study into 3 groups according to BMI:

- A group with a normal body mass index (71%).
- One group is characterised by an overweight (21%).
- An obese group (8%).

We found the predominance of the normal BMI group in our Case Series (Table 4).

3.2 Surgical Data

3.2.1 Type of surgery

In our case series, visceral, trauma and gynaecological surgery were the most represented disciplines (Table 5).

Table 3. The division of patients into small groups according to the cardiovascular treatment initiated

	Number	Percentage %
Anti-hypertensives treatment	41	26,63%
Beta blockers	4	2,6%
CI	10	6,5%
Diuretics	3	1,95%
ECI	11	7,14 %
Renin-Angiotensin-2 antagonist	6	3,9 %
ECI -CI- Diuretics Association	4	2,6 %
Sub-dietary	3	1,94%

** CI: Calcium inhibitors; ECI: Enzyme conversion inhibitor*

Table 4. Three groups in our case series with different BMI margins

BMI margin	Number	Parentage
18.5-24.9	109	70,77%
25-29.9	33	21,42%
>= 30	12	7,81 %

** BMI: body mass index*

Table 5. The different types of surgery performed in our study

Type of surgery	Number	Parentage
Abdominal	51	33,11 %
Gynaecological	23	15 %
Orthopaedic 23 15	23	15 %
Thoracic	9	5,84 %
Maxillofacial	11	7,14 %
Neurosurgery	17	11 %
ENT	15	9,74 %

** ENT: Ear, Nose and Throat*

Summary table of the different factors included in the study (Table 6).

Table 6. The different variables in our study

Variables	Variations	Total	Percentage
Average age (years)	19-59	108	70 %
	≥ 60	46	30 %
Gender	Male	90	58,5 %
	Female	64	41,5 %
ASA status	ASA I	74	48,1 %
	ASA II	64	41,5%
	ASA III	16	10, 4%
BMI (Kg/m2)	18.5-24.9	109	70,77 %
	25-29.9	33	21,42 %
	≥ 30	12	7,81%
Co-morbidities	HTA	41	26,63 %
	Diabetes	33	21,4 %
Anti-hypertensives	NO	113	73,37 %
	YES	41	26,63 %

**ASA: American Society of Anesthesiologists; BMI: body mass index*

3.3 Incidence of PIH and EIH

A total of 154 patients were included in the final analysis.

Of these, 25 (16.2%) had post induction hypotension PIH, while 31 (20.1%) met the criteria for early intraoperative hypotension EIH and 13 (8.4%) patients had both PIH and EIH. The number of patients with an arterial catheter for continuous invasive measurements of systolic blood pressure was 12 (7.7%) (Table 7).

3.4 Analytical Study

First of all we divided our patients into 4 groups:

- Group where EIP is present.
- Group where EIP is absent.
- Group where PIH is present.
- Group where PIH is absent.

Quantitative variables are expressed as medians and interquartiles, while qualitative variables are expressed as numbers and percentages. The comparison of PIH, EIP and normo-tensioned groups was done by Wilcoxon tests for quantitative variables and by Fisher's exact tests for qualitative variables. Univariate and multivariate analysis of factors associated with the occurrence of hypotension was performed by logistic regression. A *P*-value = 0.05 was considered significant.

3.4.1 In univariate analysis

Patients with PIH were statistically older than patients without PIH; [59.2 ± 11] versus [57.8 ± 13] with a [*P* value of 0.04], however there was no significant difference between the two groups in terms of sex (the sex ratio in the PIH and non-PIH groups is almost equal. [*P* value = Not significant NS]).

Both for BMI as there was no correlation between body mass index and the presence or absence of PIH [*P*-value=NS].

It was found that patients with lower baseline (pre-induction) SBP tended to develop more PIH; [120(105- 135)] versus [135(125-155)] with a [*P* value =0.05].

In terms of hypertension, it was concluded that hypertension is a major factor in the development of PIH with a [*P* value = 0.021].

Patients in the EIH group, compared to those without EIH, were statistically significantly better in terms of age [(60.01±10) versus (59.2±11)] with a [*P* value = 0.01] as well as for hypertension with a [*P* value =0.004].

Patients with lower baseline (pre-induction) SBP developed more EIH [(125(115-145) versus 135 (125-155)] with a [*P* value = 0.05].

For both parameters (SEX and BMI) there was no significant difference [*P* value = NS]. Patients with and without EIH had the same sex ratio; the sex ratio in the PIH and non-PIH groups is almost equal [*P* value = NS]. [*P* value = NS] (no correlation between SEX and EIH). As well; BMI rates very close with a [*P* value not significant] (Table 8).

3.4.2 In multivariate analysis

In multivariate analysis we retained age and pre-induction SBP as factors independently related to the occurrence of PIH. For EIH, the coexistence of chronic hypertension was a factor independently related to the occurrence of EIH in addition to age and low pre-induction SBP (Table 9).

4. DISCUSSION

4.1 Incidence of Intraoperative Hypotension

Over the last decade the risk factors for PIH and EIH have been widely studied and, despite the existing variations in population, patient age, ASA classification, comorbidities, drugs, general anaesthetic agents, and sample sizes in the different studies, only one comprehensive systematic review of the risk factors associated with intraoperative hypotension has been published to date. The subject of intraoperative hypotension, particularly post induction and early hypotension, has been a topic of great interest in the scientific community.

The incidence of per operative hypotension, post induction (Post Induction Hypotension), "PIH" or that which occurs between the induction of anaesthesia and the start of surgery "Early Intraoperative Hypotension" (EIH) which corresponds to arterial hypotension occurring during the first 30 minutes of surgery was very variable according to the published studies ranging from 9% for Reich et al. [10] and 51,25% for Kaydu et al. [17] who used ultrasound measurement of carotid intima-media thickness to predict hypotension after induction of general anaesthesia A summary table was made to have a better analysis of all the data, with two columns, one corresponding to the incidence of PIH and the other to the incidence of EIH.

It was noted that the incidence of both PIH and EIH varies according to the definitions adopted and the measurement methods of each study.

According to our study, which was carried out on 154 patients; we were able to determine the incidence of PIH at 16.23%, as well as the incidence of EIH at 20.12%. These figures are close to the study of S. Südfeld in Germany, which on 2037 patients, concluded that the incidence of PIH is 18.1% and that of EIH is 24.7% [15] (Table 10).

We hypothesised that different factors induce arterial hypotension during different phases of surgery under general anaesthesia; therefore, we defined different phases of intraoperative hypotension and identified factors associated with general anaesthesia-related hypotension in the post-induction and early intraoperative phases.

The main results of this prospective analysis can be summarised as follows:

In general surgery patients under general anaesthesia, older age and lower pre-induction baseline SBP are associated with an increased risk of PIH or EIH, as well as hypertension being a favourable factor for developing post-induction hypotension.

In terms of BMI, whatever the weight status of the patient (lean, overweight, obese), there was no correspondence with the risk of occurrence of intraoperative hypotension. Our study further demonstrated that for SEX, there was no significant value. [P-value =NS] (the sex ratio in the group with and without PIH and/or EIH is almost equal).

Table 7. Summary table showing the incidence of PIH and EIH according to the different factors

Variables	Variations	Total (%)	Absent (%)	PIH (%)	EIH (%)
Number		154	98	25 (16,2)	31 (20,1)
Average age (years)		58,5 ± 12	57,8 ± 13	59,2 ± 11	60,01 ± 10
Gender	Male	90 (58,4)	53 (54)	20 (80)	17 (54,8)
	Female	64 (41,5)	45 (46)	5 (20)	14(45,2)
ASA status	ASA I	74 (48,1)	52 (53)	10 (40)	12 (38,7)
	ASA II	64 (41,5)	42 (43)	10 (40)	12 (38.7)
	ASA III	16 (10,4)	4 (4)	5 (20)	7 (22,5)
BMI (Kg/m2)	8.5-24.9	109(70,7)	76 (77 ,5)	15 (60)	18 (58,2)
	25-29.9	33 (21,42)	20 (20,4)	6 (24)	7 (22.5)
	≥ 30	12 (7,81)	2 (2)	4 (16)	6 (19.3)
Co-morbidities	HTA	41 (26,6)	18 (18)	10 (40)	13 (42)
	Diabetes	33 (20,4)	18(18,3)	7(28)	8(25,8)
Anti-Hypertensives	NO	113(73,37)	80 (82)	7(28)	8(25,8)
	YES	41 (26,6)	18 (18)	15 (60)	18 (58)
Systolic blood pressure Pre-induction (mmHg)		137 (125-155)	135 (125-155)	120(105-135)	125 (115-145)
Anti Hypertensives	IEC	11 (7,14)	5 (5,1)	2 (8)	4 (13)
	IC	10 (6,5)	7 (7,14)	1 (4)	2 (6,45)
	ARA 2	6(3,9)	4(4)	1 (4)	1 (3,225)

**ASA: American Society of Anesthesiologists; BMI: body mass index*

Table 8. The relationship between the different factors and the presence or absence of PIH and EIH

Variables	PIH		*P*-value	EIH		P-value
	Present N = 25 (16,2)	Absent N =129(83,7)		Present N = 31 (20,1)	Absent N=123 (79,8)	
Age(years)	59,2 ± 11	57,8 ± 13	0,04	60,01 ± 10	59,2 ± 11	0.05
Gender	1,5 (15/10)	1,52 (78/51)	NS	1,58 (19/12)	1,6 (76/47)	NS
BMI (Kgm-2)	24.5	25.3	NS	24,9	25.1	NS
HBP	10 (40)	15 (60)	0,021	13 (42)	18(58)	0,004
SBP Pre-induction (mm Hg)	120 (105-135)	135 (125-155)	0.05	125 (115-145)	135 (125-155)	0.05

**BMI: body mass index; SBP: systolic blood pressure; HBP: hight blood pressure*

Table 9. Independent variables and categories of variables significantly associated with post-induction and early intraoperative hypotension

Variables	OR (95% CI)	*P*-Value
Post induction hypotension		
Age (years)	1.04 (1.02-1.06)	0.01
Pre-induction SBP mm Hg	0.87 (0.87-0.88)	0.01
Early intraoperative hypotension		
Age (years)	1.03 (1.03-1.07)	0.01
Pre-induction SBP mm Hg	0.88 (0.88-0.89)	0.01
HTA	1,75 (1,25-2.66)	0.01

**CI: confidence interval; OR: Odds Ratio; SBP: systolic blood pressure*

Table 10. Incidence of post induction and early intraoperative hypotension in the different studies

Author	Year	Country	Type	Number	Incidence of PIH	Incidence of EIH
Reich et al. [10]	2005	USA	Obs	3904	9%	-
Morley et al. [11]	2010	Ukraine	Obs	130	-	-
Lin et al. [12]	2011	China	Obs	1017	76,5%	-
Morimoto et al. [13]	2015	Japan	Obs	72	56,94 %	-
Zhang et al. [14]	2016	USA	Obs	90	46,67%	-
Südfeld et al. [15]	2017	Germany	Obs	2037	18,1%	24,7%
Jor et al. [16]	2018	Republic Czech	Obs	661	36,5%	23,14%
Kaydu et al. [17]	2018	Turkey	Obs	82	51,25%	-
Okamura et al. [18]	2019	Japan	Obs	82	45,12%	-
Tarao et al. [19]	2021	Japan	Obs	200	32%	-
Netsanet [20]	2021	Ethiopia	Obs	424	-	21,2%
Our study	2022	Morocco	Obs	154	16,23%	20,12%

**obs: observational stydy*

4.2 Age of Patients

Our study found that the average age of patients scheduled for surgery under general anaesthesia was 58.5 ± 12 years.

This result is parallel with a number of previous studies. Such as Morimoto's 2015 study in Japan on 72 patients under general anaesthesia where the mean age of the patients admitted was 61.7±11.7 years [13], and S. Südfeld's 2017 study in Germany on a respectable number of patients of 2037, which concluded that the mean age of the patients was 60 years [15]. Then comes Okamura in 2019 in Japan on 82 patients, who found that the average age of those admitted under general anaesthesia was 61 years [18].

A study done by Zhang in 2016 in America on 90 patients, operated under general anaesthesia showed that the average age of the patients was slightly decreased and corresponded to a value of 52±17years [14], also by Jor in 2018 in the Republic of Check, where the study which included 661 patients found that the average age was lower than our study with a value of 55years [16].

The year 2018 in Turkey, Kaydu through his study of 80 patients found that the average age of candidates was very low at a value of 41.6±16 years [17].

Finally, the study by the Japanese Tarao the previous year found a higher average age of 69.5±12 years in 200 patients than our study [19].

4.3 Gender of Patients

In our case series, the 154 patients studied were divided into 90 men (58.4%) and 64 women (41.5%). According to these statistics, we noted a predominance of males in our study with a sex ratio of 1.4. This predominance has been found by several researchers, such as the German S. Südfeld who found in 2017 on a series of 2037 patients, 1136 (55.8%) males against 901 (44.2%) with a sex ratio of 1.26 [15]. thus the Japanese Tarao, who found in 2021 on a series of cases of 200 patients a predominance of male sex with 123 men (66.5%) for 77 women (33.5%) and a ratio index of 1.59 [19]. On the other hand, in 2019, the study by Okamura of 82 patients in Japan showed a predominance of females with (56.1%) females to (43.9%) males, with a sex ratio of 0.78 [18].

4.4 Body Mass Index

Based on the body mass index in our study, we could define 3 groups of patients:

- -A first group of 109 (70.77%) patients with normal body mass index between [18.5-24.9].
- -A second group of 33 (21.42%) patients were overweight [25-29.9].
- -A third group of 12 (7.81%) patients who are obese [>30].

With a clear predominance of the first group with a normal BMI.

Comparing ours with previous studies, we can say that the majority of other authors are characterised by a predominance of the normal body mass index group, for example the study by Tarao from Japan in 2021 on 200 patients, which is characterised by a predominance of the normal BMI group (17.9 <BMI<29.1) [19]. and the 2019 study by Okamura from Japan on 82 patients, which found that the majority had a normal BMI (21.0<BMI<26.4) [18]. In contrast, the 2017 study by Südfeld on 2037 patients was characterised by a predominance of the overweight group (22.6<BMI<28.9) [15].

4.5 High Blood Pressure

For chronic hypertension, the statistical data of our study showed a frequency of 26.62%, i.e. for 154 patients admitted according to the criteria of our study, only 41 had chronic hypertension.

By taking a look at the literature we could compare our work with other authors. Firstly, S. Südfeld, in 2017, who found that of these 2037 patients, he found that just 773 had hypertension with a percentage of 37.9% [15]. Then in 2021 by Tarao, who did a study of 200 patients and found that the percentage of patients who are Hyper tense is 83% with 166 patients [19].

4.6 Pre-Induction Systolic Blood Pressure

In our study, pre-induction systolic blood pressure is a predisposing factor for intraoperative and early hypotension.

Compared to previous studies on factors associated with intraoperative hypotension, some of our results deserve further discussion.

In our study, a lower baseline SBP, measured directly before induction of anaesthesia, was independently associated with PIH and EIH in our general patient population.

Based on the literature, we compared our results with some studies, and we found that there is a similarity with the study of the German S.Südfeld from 2017, which reports that patients who presented with PIH also had low pre-induction SBP (SBP <130 mm Hg) [15].

The association between pre-induction SBP values and intraoperative hypotension has already been studied and discussed, our results on this issue are in line with recent data from Cheung and colleagues who show that preoperative hypotension was predictive of intraoperative hypotension in their statistical model [21].

The means by which this finding could be used in the prevention of intraoperative hypotension remain to be determined. Discontinuation of renin-angiotensin aldosterone system antagonists in patients with chronic hypertension has been shown to decrease the risk of intraoperative. This could, in theory, be due in part to an increase in SBP values prior to induction, which in turn could reduce the risk of intraoperative hypotension.

Whether treatment of intraoperative hypotension can be beneficial is unclear and requires further study. It should be noted that, especially in asymptomatic patients, low baseline blood pressure values may be chronic and have therefore led to an adjustment of the vascular autoregulation curve.

Therefore, slightly lower intraoperative SBP values can be tolerated in this subgroup of patients. Others have elaborated on the role of preoperative hypertension and the indication for pre-treatment, even at the expense of timely surgery, and have concluded that, if not extreme, hypertensive SBP values are tolerable if the haemodynamics are treated carefully in the intraoperative period [22].

Furthermore, it remains to be determined whether lowering baseline SBP values, which has been shown to normalise vascular autoregulatory ranges, would be feasible given the urgency of many surgical procedures in our patient population [23].

However, preventive elevation of preoperative baseline values, for example by volume loading or use of catecholamines prior to induction, may mitigate some of the adverse haemodynamic effects of anaesthetics [24,25].

The results of our study can be used as a basis for indicating such proactive measures.

Given the association between IOH and adverse postoperative outcomes, IOH should be avoided and treated in a timely manner. The choice of therapeutic interventions is a matter of ongoing debate, as it remains unclear which treatment strategies substantially affect outcome [26]. Common therapeutic approaches are the use of vasoactive agents - in particular vasopressors - and fluid [27]. However, there is still no uniform consensus on which vasopressors should be used to increase vascular tone and increase BP during surgery [28]. Large randomised trials are needed to answer the question of which treatment strategy should be used to avoid or treat intraoperative hypotension [29].

5. CONCLUSION

There are distinct phases of intraoperative hypotension that differ in the underlying causal mechanism leading to arterial hypotension. We investigated post-induction hypotension and early intraoperative hypotension in this prospective study, which demonstrates that low pre-induction blood pressure, older age and comorbidity such as hypertension are factors independently associated with PIH and EIH. Furthermore, we found that obesity or gender were not necessarily associated with the risk of occurrence of intraoperative hypotension. Although further research is needed to characterise the prevalence and causes of the different phases of intraoperative hypotension, these findings may allow for preventive optimisation of risk through the early implementation of continuous haemodynamic monitoring and intervention for both PIH and EIH.

CONSENT

As per international standard or university standard, patient's consent has been collected and preserved by the authors.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Weiser TG, et al, Estimate of the global volume of surgery in 2012: An assessment supporting improved health outcomes, Lancet Lond. Engl. 2015;38(Suppl 2):S11. DOI: 10.1016/S0140- 6736(15)60806-6
2. Pearse RM, et al. Mortality after surgery in Europe: A 7-day cohort study, Lancet Lond. Engl. 2012;380(9847):1059-1065. DOI: 10.1016/S0140-6736(12)61148-9
3. Vascular Events in Noncardiac Surgery Patients Cohort Evaluation (VISION) Study Investigators et al. Association between complications and death within 30 days after noncardiac surgery, CMAJ Can. Med.

Assoc. J. J. Assoc. Medicale Can. 2019; 191(30):E830-E837.
DOI: 10.1503/cmaj.190221

4. Bijker JB, van Klei WA, Kappen TH, van Wolfswinkel L, Moons KGM, Kalkman CJ. Incidence of intraoperative hypotension as a function of the chosen definition: Literature definitions applied to a retrospective cohort using automated data collection, Anesthesiology. 2007;107(2): 213-220.
DOI:10.1097/01.anes.0000270724.40897.8e
5. Südfeld S, et al. Post-induction hypotension and early intraoperative hypotension associated with general anaesthesia, Br. J. Anaesth. 2017; 119(1):57-64.
DOI: 10.1093/bja/aex127
6. Tassoudis V, et al. Impact of intraoperative hypotension on hospital stay in major abdominal surgery, J. Anesth. 2011; 25(4):492-499.
DOI: 10.1007/s00540-011-1152-1
7. Venn R, Steele A, Richardson P, Poloniecki J, Grounds M, Newman P. Randomized controlled trial to investigate influence of the fluid challenge on duration of hospital stay and perioperative morbidity in patients with hip fractures, Br. J. Anaesth. 2002;88(1):65-71.
DOI: 10.1093/bja/88.1.65
8. Chang HS, Hongo K, Nakagawa H. Adverse effects of limited hypotensive anaesthesia on the outcome of patients with subarachnoid hemorrhage, J. Neurosurg. 2000;92(6):971-975.
DOI: 10.3171/jns.2000.92.6.0971
9. Bijker JB, et al. Intraoperative Hypotension and Perioperative Ischemic Stroke after General Surgery: A Nested Case-control Study. Anesthesiology. 2012;116:658–664.
Available:https://doi.org/10.1097/ALN.0b013e3182472320
10. Reich DL, et al. Predictors of Hypotension after Induction of General Anesthesia: Anesth. Anesth. 2005;101(3):622-628.
DOI:10.1213/01.ANE.0000175214.38450.91
11. Morley AP, et al. The influence of duration of fluid abstinence on hypotension during propofol induction, Anesth. Anesth. 2010; 111(6):1373-1377.
DOI: 10.1213/ANE.0b013e3181f62a2b
12. Application of an artificial neural network to predict postinduction hypotension during general anaesthesia - Taipei Medical University.
Available:https://tmu.pure.elsevier.com/en/publications/application-of-anartificial-neural-network-to-predict-postinduct
(Accessed 26 March 2022).
13. Morimoto Y, et al. Arteriosclerosis can predict hypotension during anesthesia induction in patients 40 years and older, J. Clin. Anesth. 2014;S0952-8180(14)00329-8.
DOI: 10.1016/j.jclinane.20140.06.011
14. Zhang J, Critchley LAH. Inferior Vena Cava Ultrasonography before General Anesthesia Can Predict Hypotension after Induction, Anesthesiology. 2016;124(3): 580-589.
DOI: 10.1097/ALN.0000000000001002
15. Südfeld S, et al. Post-induction hypotension and early intraoperative hypotension associated with general anaesthesia, Br. J. Anaesth. 2017;119(1): 57-64.
DOI: 10.1093/bja/aex127
16. Jor O, et al. Hypotension after induction of general anesthesia: Occurrence, risk factors, and therapy. A prospective multicentre observational study, J. Anesth. 2018;32(5):673-680.
DOI: 10.1007/s00540-018-2532-6
17. Kaydu A, Güven DD, Gökcek E. Can ultrasonographic measurement of carotid intima-media thickness predict hypotension after induction of general anesthesia?, J. Clin. Monit. Comput. 2019;33(5) 825-832.
DOI: 10.1007/s10877-018-0228-y
18. Okamura K, Nomura T, Mizuno Y, Miyashita T, Goto T. Preanesthetic ultrasonographic assessment of the internal jugular vein for prediction of hypotension during the induction of general anesthesia, J. Anesth. 2019;33(5):612-619.
DOI: 10.1007/s00540- 019-02675-9
19. Tarao K, et al. Risk factors including preoperative echocardiographic parameters for post-induction hypotension in general anaesthesia, J. Cardiol. 2021; 78(3):230-236.
DOI: 10.1016/j.jjcc.2021.03.010
20. Temesgen N, Fenta E, Eshetie C, Gelaw M. Early intraoperative hypotension and its associated factors among surgical patients undergoing surgery under general anesthesia: An observational study, Ann. Med. Surg. 2021;71:102835.
DOI: 10.1016/j.amsu.2021.102835

21. Cheung CC, et al. Predictors of intraoperative hypotension and bradycardia, Am. J. Med. 2015;128(5):532-538.
DOI: 10.1016/j.amjmed.2014.11.030
22. Howell SJ, Sear JW, Foëx P. Hypertension, hypertensive heart disease and perioperative cardiac risk, Br. J. Anaesth. 2004;92(4):570-583.
DOI: 10.1093/bja/aeh091
23. Effects of different classes of antihypertensive drugs on cerebral hemodynamics in elderly hypertensive patients - PubMed.
Available:https://pubmed.ncbi.nlm.nih.gov/16364836/
(Accessed 13 March 2022).
24. Ngan Kee WD, Khaw KS, Ng FF, Lee BB. Prophylactic phenylephrine infusion for preventing hypotension during spinal anesthesia for cesarean delivery, Anesth. Anesth. 2004;98(3):815-821.
DOI:10.1213/01.ane.0000099782.78002.30
25. Ripollés Melchor J, et al. Colloids versus crystalloids in the prevention of hypotension induced by spinal anesthesia in elective cesarean section. A systematic review and meta-analysis, Minerva Anestesiol. 2015;81(9):1019-1030.
26. Sessler DI, et al. Perioperative Quality Initiative consensus statement on intraoperative blood pressure, risk and outcomes for elective surgery, Br. J. Anaesth. 2019;122(5):563-574.
DOI: 10.1016/j.bja.2019.01.013
27. Saugel B, et al. Automated Ambulatory Blood Pressure Measurements and Intraoperative Hypotension in Patients Having Noncardiac Surgery with General Anesthesia: A Prospective Observational Study, Anesthesiology. 2019 ;131(1):74-83.
DOI: 10.1097/ALN.0000000000002703
28. Mitchell K, Adams D, McHugh SM. Organ Dysfunction After Surgery in Patients Treated With Individualized or Standard Blood Pressure Management, JAMA. 2018;319(7):719-720.
DOI: 10.1001/jama.2017.20948
29. Wijnberge M, et al. The use of a machine-learning algorithm that predicts hypotension during surgery in combination with personalized treatment guidance: Study protocol for a randomized clinical trial, Trials. 2019;20(1):582.
DOI: 10.1186/s13063-019-3637- 4

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/91856