Controlled hypotension in maxillofacial surgery: a commentary

Manlio Barbarisi[1], Diana Abbenante[2], Francesca Piccialli[2], Francesco Coppolino[2], Luca Gregorio Giaccari[2], Maria Caterina Pace[2], Vincenzo Pota[2], Pasquale Sansone[2], Caterina Aurilio[2]

[1]Department of Medical, Surgical, Neurological, Metabolic and Aging Sciences, University of Campania "L. Vanvitelli", Naples, Italy; [2]Department of Women, Child, General and Specialistic Surgery, University of Campania "L. Vanvitelli", Naples, Italy

Correspondence to: Caterina Aurilio, MD. Department of Women, Child, General and Specialistic Surgery, University of Campania "L. Vanvitelli", Piazza Miraglia 2, 80138 Naples, Italy. Email: caterina.aurilio@unicampania.it.

Keywords: Controlled hypotension; induced hypotension; hypotensive anesthesia; orthognathic surgery; maxillofacial surgery

Received: 16 February 2023; Accepted: 26 September 2023; Published online: 27 September 2023.

doi: 10.21037/joma-23-6

View this article at: https://dx.doi.org/10.21037/joma-23-6

Introduction

Controlled hypotension is defined as a reversible lowering of the baseline mean arterial pressure (MAP) of 30% and maintained around 60–70 mmHg (1,2). There are numerous fields of application of this method, one of the most important is maxillofacial surgery which requires a bloodless operating field ("dry" operation area) to allow easier identification of the anatomical structures, as well as the reduction of complications related to intraoperative bleeding and need of blood transfusions (3). Furthermore, in this way, the surgical times are also reduced (1,4,5). There is heavy bleeding in maxillary osteotomies from injury to the descending palatine artery, sphenopalatine artery, or pterygoid venous plexus, sometimes from injury to the second part of maxillary artery. Furthermore, during mandibular osteotomies, major bleeding may occur due to injury to the masseteric artery, retromandibular vein, or pterygoid venous plexus, or sometimes a lesion of the facial artery (6). Bleeding can be further reduced if local injection of epinephrine is performed simultaneously with hypotensive anesthesia (7). However, controlled hypotension can involve various risks for the patient who must therefore be carefully studied before undergoing the treatment. Particular attention to tissue damage due to hypoperfusion borne by vital organs that is brain, heart, liver, and kidney must be given.

So being a sophisticated technique, it requires a certain experience on the part of the anesthetist as well as knowledge of contraindications and wise management of appropriate monitoring systems to avoid ischemic damage (3).

There are compensatory mechanisms that guarantee a safety margin during controlled hypotension (4). One of the main ones being the ability to self-regulate the cerebral blood flow and therefore the tolerance limits of the brain to hypotension. The minimum MAP limit value in adults with normal blood pressure is 70 mmHg, considering that it exists a variability between individuals of this value and the efficiency of the cerebral blood flow self-regulation system. There is also a reserve of blood flow which buffers the central nervous system (CNS) in the face of a reduction in blood flow to critical levels during hypotension. However, the MAP threshold value at which symptoms of cerebral ischemia can arise is probably 40–50 mmHg in normotensive adult subject in the orthostatic position and 45–55 mmHg in the supine position (8).

Contraindications to induced hypotensive anesthesia are conditions that can determine a reduced organ perfusion, for example aortic stenosis, obstructive and restrictive cardiomyopathy, left ventricular hypertrophy, myocardial infarction for less than 6 months, carotid stenosis, uncontrolled arterial hypertension, previous stroke, hypovolemia, and pregnancy (4).

This article was performed to study the current evidence on the risks and benefits of controlled hypotension in maxillofacial surgery, to assess whether this kind of methodology can be routinely used in such surgery system or not. Furthermore, we described how to perform controlled hypotension, focusing on the most commonly anesthetic drugs currently used in

Table 1 Search method

Items	Specification
Date of search	September 4, 2022
Databases and other sources searched	PubMed, Cochrane Central Register, Drugs and Food and Drug Administration
Search terms used	"Controlled hypotension", "deliberate hypotension", "induced hypotension", "hypotensive anaesthesia", "orthognathic surgery", and "maxillo-facial surgery"
Timeframe	Until August 31, 2022
Inclusion criteria	No language restriction
Selection process	Eligibility was determined by reading the abstract of each study obtained by the search. Studies were excluded when they clearly did not satisfy inclusion criteria and obtained full copies of the remaining studies. Two of the authors (Barbarisi M and Abbenante D) fully read these studies in independent way and reached agreement by discussion

total intravenous anesthesia (TIVA) and in balanced anesthesia, without forgetting the importance of other drugs, such as coadjutants, which can be added to the main hypotensive drug.

Methods

We performed this study by identifying the articles by searching electronic databases (PubMed, Cochrane Central Register, Drugs and Food and Drug Administration). Other relevant publications were identified from the bibliography.

The terms used for our research were "controlled hypotension", "deliberate hypotension", "induced hypotension", "hypotensive anaesthesia", "orthognathic surgery", and "maxillo-facial surgery".

The publications included in this commentary evaluated controlled hypotension in maxillofacial surgery. No language restriction was applied. The first search was conducted on September 4, 2022.

Eligibility was determined by reading the abstract of each study obtained by the search. Studies were excluded when they clearly did not satisfy inclusion criteria and obtained full copies of the remaining studies. Two of the authors (Barbarisi M and Abbenante D) fully read these studies in an independent way and reached an agreement by discussion.

The search method is summarized in *Table 1*.

Results and discussion

Maxillofacial surgeons need a possibly bloodless operative field due to the particular characteristics of the area in which only a few drops of blood can prevent the vision. Controlled hypotension is a good solution due to the high level of difficulty in controlling bleeding through the use of clamps on afferent vessels. Several randomized controlled trials have demonstrated the efficacy of a lot of controlled hypotension techniques in reducing bleeding and improving the quality vision of the surgical field. Pharmacological measures were associated with physical measures (for example the 15-degree tilt position). Esmolol, clonidine, and remifentanil have been used successfully (5).

Effects on the main vital organs

All organs react to hypotension differently. The brain and the heart tolerate periods of severe hypotension poorly rather than prolonged levels of hypotension of acceptable magnitude. Sudden hypotension can pose a risk to all organs.

CNS

The range of limit values within which brain self-regulation is maintained is between 50 and 150 mmHg. In addition to this, it is recommended to keep the patient in normocapnia status [CO_2 partial pressure ($PaCO_2$) between 35–40 mmHg] (9). In anesthesia, it must be considered that there are also drugs that affect brain self-regulation. The desflurane, for example, tends to increase intracranial pressure (ICP) starting from alveolar concentrations of 0.55 minimum alveolar concentration (MAC), but the effect is even more pronounced at 1.5 MAC (9).

Respiratory system

The reduction of pulmonary alveolar macrophage (PAM), associated with the anti-Trendelenburg position or sitting position, increases dead alveolar space, with the risk of hypoxia and hypercapnia (10). In addition to this, particular attention should be paid when using positive end-expiratory pressure (PEEP) in the aerial pathways (10).

Heart

In conditions of hypotension, if drugs with a bradycardizing effect are not used, the patient's cardiac frequency (CF) increases to keep constant cardiac output (9). Coronary perfusion depends on PAM and diastolic pressure. Tachycardia reduces the time of diastolic perfusion and increases oxygen consumption, being able to create an imbalance between oxygen availability and oxygen consumption, and thus induce ischemic suffering, especially at the subendocardial level (9). This may occur in patients with stenotic coronary arteries.

Kidney

The most important risk factors for the development of postoperative acute renal failure (ARF) are: advanced age, the presence of heart disease, preoperative renal failure and the most relevant precipitating factor is precisely the hypotension, both absolute or relative, that occurs during the intervention or in the postoperative period. To all these factors can be added the use of nephrotoxic agents (11). Patients with preoperative chronic renal failure (CRF) are concerned, it has been noted that the likelihood of developing ARF in the postoperative period (defined as an increase in creatininemia >0.5 mg/dL) increases if you maintain a PAM <55 mmHg for more than 60–70 minutes (12).

Pharmacological means

The characteristics of an ideal hypotensive agent should be: easy to administer, rapid onset and a rapid offset, rapid elimination without toxic metabolites, and a predictable dose-dependent effect.

Clonidine

Clonidine is a centrally acting alpha2-adrenergic agonist imidazole derivative and it has a powerful antihypertensive action. Its use entered clinical practice in 1974, in the United States. Both acute and chronic administration determine a significant reduction in MAP, an effect enhanced if simultaneously administered vasodilators or diuretics. Other effects are a reduction in sympathetic tone in the heart, kidneys, and peripheric vessels with a simultaneous increase in vagal tone. Hemodynamically it causes a decrease in supine and erect blood pressure, heart rate, peripheral resistance, plasma renin activity, and urinary aldosterone and catecholamine excretion. Major side effects are rare (13).

Remifentanil

Remifentanil is the closest drug to an ideal hypotensive agent model (rapid onset of action, rapid end of effect, easily modulated dose-dependent effect, and absence of toxic metabolites). It is a short-acting opioid and it is a mu receptor agonist.

Remifentanil has an onset of about 1 minute and a context-sensitive half-life of about 5 minutes, in fact it is metabolized by plasma esterases (14). The pharmacokinetics of remifentanil are therefore independent of the total dose and duration of infusion. The administration of remifentanil leads to a reduction in MAP, heart rate and lowers cerebral blood flow and pressure-induced constriction (PIC). The action on the reduction of arterial pressure occurs with the inhibition of the central and autonomous system. Furthermore, remifentanil seems to produce the synthesis of prostacyclin and nitric oxide (NO) and the release of histamine.

Propofol (2,6-diisopropylphenol)

The action of propofol increases the inhibitory function of the neurotransmitter gamma-aminobutyric acid (GABA) through GABA type A (GABAA) receptors. It is extensively metabolized and eliminated in the urine as glucuronide conjugates. Propofol reduces blood pressure primarily through an effect directed on cardiac inotropism, however it also has a venodilating effect. It also preserves cerebral self-regulation and keeps the relationship between metabolism and cerebral blood flow (15).

Halogenated

The most commonly used inhalation anesthetics are desflurane and sevoflurane, at concentrations between

0.5 and 1.3 MAC (16). The exact mechanism of action of inhaled anesthetics has not been established. Desflurane and Sevoflurane administered by inhalation appear to act on the lipid matrix of the neuronal membrane, with consequent interruption of neuronal transmission in the brain.

Desflurane

Desflurane is a halogenated ether inhalation general anesthetic agent with low solubility in blood and body tissues. The low solubility of desflurane facilitates a rapid induction of anesthesia and precise control of the depth of anesthesia (during maintenance).

Sevoflurane

Sevoflurane is an ether inhalation general anesthetic agent. It has a lower solubility in blood than isoflurane or halothane but not desflurane. This low solubility and the absence of pungency facilitate rapid mask induction; the low blood solubility also expedites "wash-out" and therefore recovery from anesthesia. Sevoflurane produces dose-dependent CNS, cardiovascular, and respiratory depressant effects (17).

Desflurane and sevoflurane have a hypotensive action because they dilate the small arterial vessels (18). Some studies show that desflurane is less effective in inducing controlled hypotension than sevoflurane, and that desflurane is associated with an increase in heart rate, MAP, and PIC, but it has shorter recovery times (19-21).

In another scientific work it emerged that anesthesia conducted with desflurane can reduce blood loss more than sevoflurane and could give an acceptable surgical field with mild controlled hypotension and with a substantial reduction in the vasoactive drug requirement (22).

Magnesium

Magnesium is a non-competitive antagonist of N-methyl-D-aspartate (NMDA) receptors, reduces the release of catecholamines, reduces the response to the surgical stimulus and sensitization of the peripheral nociceptor. It activates membrane calcium adenosine triphosphatase (ATPase) and consequently acts as a membrane stabilizer (23). Magnesium acts as a vasodilator and angiotensin-converting enzyme (ACE) inhibitor, and thus reduces systemic vascular resistance (23). All these properties explain the hypotensive effect of magnesium and for this reason magnesium can be used as an adjuvant in controlled hypotension, and it's use has also been recommended in patients with cardiac arrhythmias and arterial hypertension during general anesthesia.

Beta-blockers: esmolol

Among the beta-blocking drugs most used in controlled hypotension, we find esmolol. It is a cardio-selective drug, with antagonistic action on β1 receptors. The hypotensive effect is related to the reduction of cardiac output and the inhibition of renin synthesis (24). Esmolol has a negative inotropic and chronotropic effect and does not cause reflex tachycardia, indeed it can be used to reduce reflex tachycardia that can be associated with the use of other hypotensive agents. It does not cause rebound hypertension (24).

Fenoldopam

Fenoldopam is a dopamine (D1) receptor agonist that produce a decreased peripheral vascular resistance primarily in renal capillary beds, thus promoting increased renal blood flow, natriuresis, and diuresis (25). Fenoldopam was recently used to induce controlled hypotension, however, it has a high treatment cost that limits their development in this indication (5).

Non-pharmacological means

Other studies investigated controlled hypotension achieved by placing the patient in anti-Trendelenburg or performing acute normovolemic hemodilution (26,27). Both techniques are relatively safe, but are highly dependent on the patient's cardiac output.

Also, Valsalva maneuver can improve hemostasis and it was largely studied in thyroidectomy surgery (28). This technique improves the identification of bleeding points and the effectiveness of postoperative drainage. When used in head and neck surgery, the Trendelenburg position is vastly superior to the Valsalva maneuver (29).

Indications and contraindications

Operations with increased risk of bleeding include Le Fort osteotomies, maxillectomy for tumor resection, resection of tumor from the tongue and floor of the mouth, and neck dissections. In these procedures, the use of hypotensive anesthesia can reduce intraoperative bleeding by helping the surgeon perform the required surgical procedure.

Controlled hypotension is contraindicated in patients in whom a drop in blood pressure is unsafe. These are patients with disseminated vascular disease, ischemic heart disease, and carotid stenosis. They are candidates for normotensive blood pressure control strategies. In other cases, hypotensive anesthesia is considered to be a suitable anesthetic technique for major maxillofacial operation.

We recommend identifying procedures where high blood loss is expected and limiting the use of hypotensive anesthesia technique to those procedures where patients are most likely to benefit.

Conclusions

The goal of controlled hypotension is to reduce operative bleeding conserving blood. It is indicated in the reduction of operative bleeding for surgeries that require a bloodless operating field and for interventions that have moderate bleeding potential, such as maxillofacial surgery and other surgeries (microsurgery, ophthalmological surgery, and neurosurgery) in light of the risk/benefit ratio. The hypotensive effect of inhalation agents, or TIVA with propofol and remifentanil avoids the use of less manageable hypotensive agents and, therefore, improves the risk/benefit ratio. Over the last 10 years, new drugs to obtain controlled hypotension have been used: remifentanil and sevoflurane, clonidine, and adenosine and fenoldopam (5). Last of all, controlled hypotension in maxillofacial surgery is definitely advantageous, but it requires both a meticulous selection and an adequate intraoperative monitoring system of the patients.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the editorial office, *Journal of Oral and Maxillofacial Anesthesia*. The article has undergone external peer review.

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://joma.amegroups.com/article/view/10.21037/joma-23-6/coif). CA serves as an unpaid editorial board member of *Journal of Oral and Maxillofacial Anesthesia* from December 2021 to November 2023. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References

1. Degoute CS. Controlled hypotension: a guide to drug choice. Drugs 2007;67:1053-76.
2. Alkan A, Honca M, Alkan A, et al. The efficacy of esmolol, remifentanil and nitroglycerin in controlled hypotension for functional endoscopic sinus surgery. Braz J Otorhinolaryngol 2021;87:255-9.
3. Sollevi A. Hypotensive anesthesia and blood loss. Acta Anaesthesiol Scand Suppl 1988;89:39-43.
4. Prasant MC, Kar S, Rastogi S, et al. Comparative Study of Blood Loss, Quality of Surgical Field and Duration of Surgery in Maxillofacial Cases with and without Hypotensive Anesthesia. J Int Oral Health 2014;6:18-21.
5. Testa LD, Tobias JD. Pharmacologic drugs for controlled hypotension. J Clin Anesth 1995;7:326-37.
6. Rodrigo C. Induced hypotension during anesthesia with special reference to orthognathic surgery. Anesth Prog 1995;42:41-58.
7. Lin S, McKenna SJ, Yao CF, et al. Effects of Hypotensive Anesthesia on Reducing Intraoperative Blood Loss, Duration of Operation, and Quality of Surgical Field During Orthognathic Surgery: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. J Oral Maxillofac Surg 2017;75:73-86.
8. Drummond JC. Blood Pressure and the Brain: How Low Can You Go? Anesth Analg 2019;128:759-71.
9. Weaver JM 2nd. Contemporary anesthetic techniques for orthognathic surgery. Anesth Prog 1992;39:146-9.
10. Larson AG. Deliberate hypotension. Anesthesiology

1964;25:682-706.
11. Tobias JD. Sevoflurane for controlled hypotension during spinal surgery: preliminary experience in five adolescents. Paediatr Anaesth 1998;8:167-70.
12. Sharrock NE, Beksac B, Flynn E, et al. Hypotensive epidural anaesthesia in patients with preoperative renal dysfunction undergoing total hip replacement. Br J Anaesth 2006;96:207-12.
13. Sanchez Munoz MC, De Kock M, Forget P. What is the place of clonidine in anesthesia? Systematic review and meta-analyses of randomized controlled trials. J Clin Anesth 2017;38:140-53.
14. Kazmaier S, Hanekop GG, Buhre W, et al. Myocardial consequences of remifentanil in patients with coronary artery disease. Br J Anaesth 2000;84:578-83.
15. Trapani G, Altomare C, Liso G, et al. Propofol in anesthesia. Mechanism of action, structure-activity relationships, and drug delivery. Curr Med Chem 2000;7:249-71.
16. Caverni V, Rosa G, Pinto G, et al. Hypotensive anesthesia and recovery of cognitive function in long-term craniofacial surgery. J Craniofac Surg 2005;16:531-6.
17. Patel SS, Goa KL. Sevoflurane. A review of its pharmacodynamic and pharmacokinetic properties and its clinical use in general anaesthesia. Drugs 1996;51:658-700.
18. Albertin A, La Colla L, Gandolfi A, et al. Greater peripheral blood flow but less bleeding with propofol versus sevoflurane during spine surgery: a possible physiologic model? Spine (Phila Pa 1976) 2008;33:2017-22.
19. Bedforth NM, Hardman JG, Nathanson MH. Cerebral hemodynamic response to the introduction of desflurane: A comparison with sevoflurane. Anesth Analg 2000;91:152-5.
20. Shelton CL, Sutton R, White SM. Desflurane in modern anaesthetic practice: walking on thin ice(caps)? Br J Anaesth 2020;125:852-6.
21. Ryu KH, Hwang SH, Shim JG, et al. Comparison of vasodilatory properties between desflurane and sevoflurane using perfusion index: a randomised controlled trial. Br J Anaesth 2020;125:935-42.
22. Rossi A, Falzetti G, Donati A, et al. Desflurane versus sevoflurane to reduce blood loss in maxillofacial surgery. J Oral Maxillofac Surg 2010;68:1007-12.
23. Telci L, Esen F, Akcora D, et al. Evaluation of effects of magnesium sulphate in reducing intraoperative anaesthetic requirements. Br J Anaesth 2002;89:594-8.
24. Ornstein E, Young WL, Ostapkovich N, et al. Are all effects of esmolol equally rapid in onset? Anesth Analg 1995;81:297-300.
25. Nichols AJ, Ruffolo RR Jr, Brooks DP. The pharmacology of fenoldopam. Am J Hypertens 1990;3:116S-9S.
26. Barak M, Yoav L, Abu el-Naaj I. Hypotensive anesthesia versus normotensive anesthesia during major maxillofacial surgery: a review of the literature. ScientificWorldJournal 2015;2015:480728.
27. Nooraei N, Dabbagh A, Niazi F, et al. The Impact of Reverse Trendelenburg Versus Head-up Position on Intraoperative Bleeding of Elective Rhinoplasty. Int J Prev Med 2013;4:1438-41.
28. Ozdemir M, Makay O, Icoz G, et al. What adds Valsalva maneuver to hemostasis after Trendelenburg's positioning during thyroid surgery? Gland Surg 2017;6:433-6.
29. Moumoulidis I, Martinez Del Pero M, Brennan L, et al. Haemostasis in head and neck surgical procedures: Valsalva manoeuvre versus Trendelenburg tilt. Ann R Coll Surg Engl 2010;92:292-4.

doi: 10.21037/joma-23-6
Cite this article as: Barbarisi M, Abbenante D, Piccialli F, Coppolino F, Giaccari LG, Pace MC, Pota V, Sansone P, Aurilio C. Controlled hypotension in maxillofacial surgery: a commentary. J Oral Maxillofac Anesth 2023;2:22.

