Otolaryngology online journal

ISSN: 2250-0359 Volume 4 Issue 4 2014

A Retrospective Study of the Impact of Mean Arterial Pressure on Estimated Blood Loss during Endoscopic Sinus Surgery

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Abstract:

The current practice of lowering mean arterial pressure (MAP) during endoscopic sinus surgery (ESS) is common, but unproven with regard to peer reviewed literature. The controlled hypotension induced is aimed for improved surgical field and lower the blood loss. Lower mean arterial pressures especially for prolonged surgeries may result in end organ hypo perfusion. The authors reviewed all patients who underwent outpatient endoscopic sinus surgery for the diagnosis of chronic sinusitis from January 1, 2012 to December 31, 2012 at

Memorial Hermann Hospital – Texas Medical Centre. We individually reviewed case sheets of every patient and documented blood loss as recorded on the anaesthesia record or in the surgical procedure note, among other variables. A total of 326 patients were included in this study. The median estimated blood loss (EBL) was found to be 50 ml. The multivariate regression analysis between these three groups showed that EBL was higher in MAP <65 group and MAP 65-75 group compared to MAP >75 group. The average of EBL in MAP<65 group was 92% higher than that in MAP>75 group and the average of EBL in MAP 65-70 group is 42% higher than that in MAP>75 group when other variables were fixed. Hence we found the trend toward higher blood loss with lower MAP. The authors conclude that lower MAP does not result in lower EBL in endoscopic sinus surgery. Furthermore, increases in BMI and crystalloid administered during an aesthetic management of these cases correlates with increased estimate blood loss.

Introduction

Endoscopic sinus surgery is reported to be safe and commonly performed as a day care procedure [1,2]. The current practice of lowering mean arterial pressure (MAP) during endoscopic sinus surgery (ESS) is common, but unproven with regard to peer reviewed literature. The controlled hypotension induced is aimed for improved surgical field and lower the blood loss. Lower mean arterial pressures especially for prolonged surgeries may result in end organ hypo perfusion. This may be of importance to Hypoxi-sensitive nerve cell such as the brain. In previous studies factors such as patient positioning and aesthetic agent choice have been analysed to assess impacts on blood loss without specific analysis of MAP on estimated blood loss [3,4,5,6]. The primary aim of this study was to investigate if average MAP during the surgery had an effect on the estimated blood loss (EBL). We also determined the effect of total intravenous fluids on blood loss and any adverse event during the perioperative period.

Materials and Methods

Approval was obtained from the University of Texas at Houston Institutional Review Board prior to initiation of the study. The study population included all patients who underwent outpatient endoscopic sinus surgery for the diagnosis of chronic sinusitis from January 1, 2012 to December 31, 2012 at Memorial Hermann Hospital – Texas Medical Centre. A search for this patient population was conducted via an electronic medical record (EMR) query performed by the information technology department. Each aesthetic chart was reviewed for all recorded blood pressures on the intraoperative blood pressure grid following the first 15 minutes of the aesthetic. The research team individually recorded every systolic and diastolic blood pressure onto an excel spread sheet and later the MAP was calculated from these values using the standard formula (systolic blood pressure x 1/3 + diastolic blood pressure x 1/3). An average of the calculated MAPs was generated with a standard of deviation for each case. We recorded estimated blood loss as recorded on the anaesthesia record or in the surgical procedure note (if not available in the aesthetic records). Other variables collected include age, gender, weight, height, total IV fluid (crystalloid and colloid) administered, the first creatinine acquired after 1 week but before six months when available (this was compared to baseline when available), incidence of myocardial infarction, incidence of cerebral vascular incident (as documented in the hospitals EMR).

Statistical Methods

For all preoperative patient characteristics, mean standard deviation was summarized for continuous variables with normal distribution and median with interquartile range was summarized for non-normal variables. Categorical variables are reported as frequency (percentage). The relationship between EBL and patient preoperative characteristics as well as average MAP during surgery was assessed based on univariate regression model. All variables with a p-value <0.20 in univariate analysis were entered into a multivariate regression model. Stepwise selection method is used to identify significant independent factors associated with EBL. In the above models, EBL was considered as dependent variables after logarithmic transformation for normality. All statistical analyses were conducted using SAS 9.3 (SAS Institute, Cary, NC, USA). A p-value <0.05 was considered significant. A per-protocol analysis was performed.

Results

A total of 358 patients were included in this study. The study population included 178 males (49.7%) and 180 females (50.2%), with a mean age of 50.4±18.5years (range 12-86 years). The height and weight were 170.0 ±11.1 cms and 82.4±22.2 kgs respectively. The mean body mass index was 28.5±6.4. All the patients underwent ESS, for a diagnosis of chronic sinusitis or allergic fungal sinusitis. The clinical characteristics of patients in both groups were almost similar, with most of the patients presenting with nasal obstruction. Out of 358, we did not find the EBL recorded for 32 patients in either anesthesia or surgical records, so they were excluded from the study. The median EBL in 326 patients was found to be 50 ml. When MAP average during the surgery was categorized into three groups as shown in Table 1, the higher blood loss was seen in patients having MAP less than 65. When EBL was compared to MAP on a box plot as shown in Figure 1 even the 75^{th} percentile for MAP less than 65 shows the higher values for EBL. The multivariate regression analysis between these three groups showed that EBL was higher in MAP <65 group and MAP 65-75 group compared to MAP >75 group. The average of EBL in MAP<65 group was 92% higher than that in MAP>75 group and the average of EBL in MAP 65-70 group is 42% higher than that in MAP>75 group when other variables were fixed. Hence we found the trend toward higher blood loss with lower MAP. We also recorded the total crystalloid and colloid received by the patients. It was found that the patients who received more total crystalloid by weight (ml/kg in this study) had higher EBL during surgery. The analysis showed an increase of one unit in total crystalloid by weight would result in 4% increase in EBL when other variables are fixed. Body mass index was also found as a one of the statistically significant factors responsible for higher blood loss. Table 2 shows the relationship between EBL and independent factors using multivariate regression analysis. There was no incidence of cerebrovascular accident and acute myocardial infarction was found in any case.

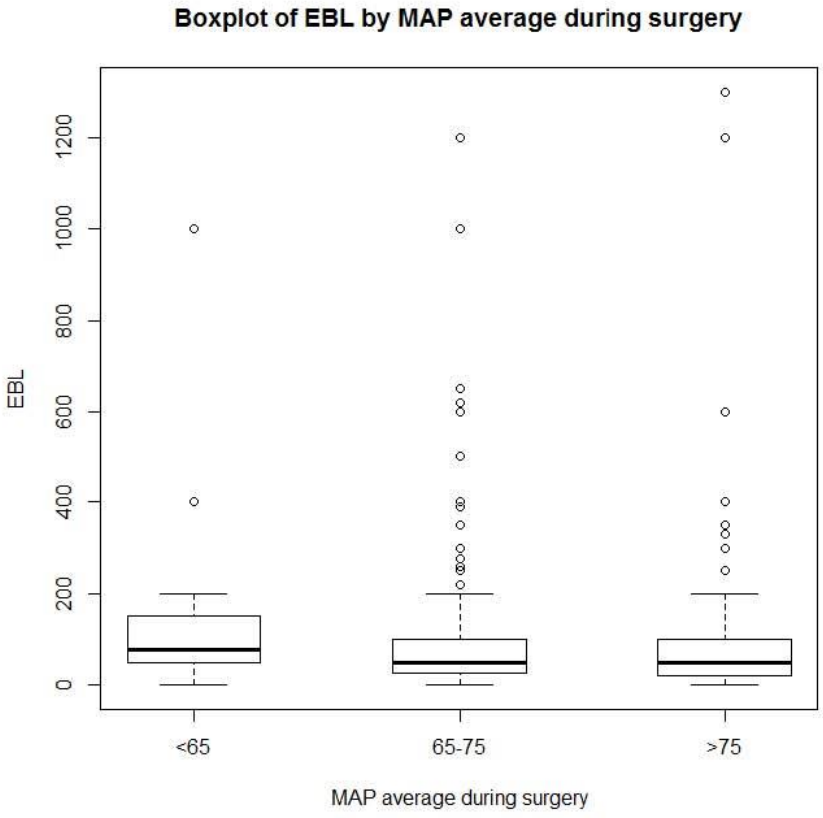
Boxplot of EBL by MAP average during surgery
EBL
0
200
400
600
800
1000
1200
<65
65-75
>75
MAP average during surgery

Figure 1

Table 1: EBL by different categories of MAP average during Surgery

	MAP average during Surgery		
	<65 (N=26)	65-75 (N=182)	>75 (N=149)
EBL, median (Q1, Q3)	77.5 (50, 150)	50 (25, 100)	50 (20, 100)

Table 2: Results from multivariate regression analysis to assess the relationship between EBL and independent factors.

Factors	Coefficients	Standard Error	**P-value**
BMI	0.040	0.010	<0.001
Male	0.336	0.126	0.008
Total Crystalloid by weight	0.044	0.010	<.0001
MAP average during Surgery	0.653	0.257	0.012
<65	0.348	0.129	0.008
65-75			
>75 (reference group)			

Discussion

This study was designed in order to assess the validity of a commonly held belief that lower MAP resulted in lower blood loss during ESS. This primary endpoint that we were assessing clearly did not correlate with the expected result according to the data charted in our hospital. An elevated MAP correlated with lower EBL in a statistically significant fashion, suggesting that lower MAP can be expected to increase blood loss. A postulated mechanism for this finding may include the application of the auto regulatory curve commonly considered for intraoperative blood pressure management. Fundamentally, a lower blood pressure would be associated with greater vasodilation, and therefore, greater potential flow of blood through the turbinate and sinusoidal vascular beds in question. Conversely, with a higher MAP, they would conceivably be greater vasoconstriction and lower blood flow in the aforementioned vascular beds, leading to lower actually measured blood loss. This application of the auto regulatory curve requires the consideration that, in ESS under general anaesthesia, hypotension correlates with vasodilation likely induced by the aesthetic. Conventional thinking by the authors prior to reviewing this data would have surmised that lower blood pressure in this population under these circumstances simple resulted in less flow as the primary mechanism of lower MAP, instead of lower vascular resistance.

We divided the MAP in to the three described groups (<65 mmHg, 65-75 mmHg, >75 mmHg) in order to appropriately analyse the clinical outcomes associated with the various recorded blood pressures. At our institution, we do not induce deliberate hypotension to a pre-specific blood pressure, though our surgeons frequently request a 'lower' blood pressure in order to minimize blood loss. The autoregulation curve is generally thought to end at a MAP between 50-70, depending on the textbook reference [7,8]. We choose the 'low' blood pressure group to overlap with the lower end of the generally accepted autoregulation curve, which bends somewhere near 70 mmHg in humans. A MAP of >75mmHg at our institution is considered normotensive in a patient without pre-existing hypertensive disease, and as such it was our 'high' range. This range is not intended to reflect clinical hypertension in any respect. Our 'middle' blood pressure range correlated with the MAP between the two groups as described.

The pattern of lower EBL with lower MAP held for all blood pressures less than 75 mmHg with statistical significance. We are confident that our MAP data is valid because of the extensive effort taken to manually enter the records systolic and diastolic blood pressures leading to the calculation of the MAP, while excluding the hemodynamically turbulent period of induction, which could confound our results. The quantity of hemodynamic values acquired in this study is in excess of 22,000 discrete data points. The authors recognize that the finding of lower EBL with higher MAP is counterintuitive and will hopefully be further studied in a prospective fashion as a result of our findings.

Greater crystalloid administration resulted in greater EBL as well, correlating with the mechanism discussed above: likely higher intravascular flow is appreciated in the low vascular resistance scenario of the turbinate/sinus bed under general anaesthesia. As intravascular volume increased, EBL was found to concomitantly increase. We analysed our data on an mL/kg basis in order to compensate for variation in patient size, granting greater validity to our data. Increases in BMI also correlate with increased EBL; this trend is a well-known factor associated with increased EBL in multiple types of surgery [9,10]. Since knowing EBL at surgery plays a key role in transfusion requirement, determining preoperative variable that predicts blood loss would be helpful. It was not possible for us to completely analyse the effect of colloids in general, and hydroxyethyl starch (HES) solutions in particular, in this patient population. Our protocol was designed to detect this before the general abstention from use of HES solutions following the Food and Drug Administration's (FDA) block box warning for HES products arising in late 2012 [1]. The number of patients receiving HES or albumin was too low for us to generate meaningful conclusions regarding EBL, UOP or related outcomes.

Our study demonstrated increased EBL associated with male gender, which the authors are not able to easily explain. The impact of make gender is certainly statistically significant to a similar degree of the impact of MAP on EBL with a $p = 0.008$. Zheng et al, in their study analysing predictive factors for

blood loss in spine surgery, found that women had less intraoperative blood loss [11]. Determination of the mechanism of this finding is beyond the scope of this article; however, further analysis of coagulation function between male and female elective surgical patients may be warranted in light of these findings.

The principle weakness of our study it's retrospective design with reliance on documented EBL. While EBL as charted in the aesthetic record may not be regarded as clinically precise, evidence indicates that recorded EBL is generally accurate [12]. Nonetheless, even with a reasonable expectation of documentation imprecision, our study was designed to include a large number of patients over an entire year at our institution in order to minimize the potential effect of operator recording inaccuracy. While the principle of using a recorded EBL is not ideal, it is reliable in the opinion of the authors. As such our study indicates that at a minimum, low MAP does not reliably lead to lower EBL, in and in fact the opposite is more probable.

There were five patients with EBLs greater than 1,000ml; 2 of these patients were being operated on for carcinomas and 3 had bilateral sinus involvement with case duration in excess of 150 minutes. These statistical outliers were distributed across all three groups.

Our goal was to additionally assess the possibility of end organ damage resulting from the application of lower MAP; unfortunately, the number of patients with a collected post-operative creatinine was too low to generate any meaningful statistical analysis, and as such it has been omitted. There were no perioperative myocardial infarctions or strokes.

Conclusion

The authors conclude that lower MAP does not result in lower EBL in endoscopic sinus surgery. This conclusion considers the fact that our median EBL is already low, and therefore which we had a statistically significant result, it is difficult to infer definitive clinical significance. It can be determined however that a lower MAP is not superior to a higher EBL for the purposes of reducing clinically documented blood loss. Furthermore, increases in BMI and crystalloid administered during an aesthetic management of these cases correlates with increased estimate blood loss. Prospective studies should be conducted to further assess these findings in order to provide clinically definitive conclusions.

Acknowledgements

The authors would like to thank Dr. Carin Hagberg for her support in completing this project. Dr. Cai research was supported by the National Institutes of Health's Clinical and Translational Science Award grant (UL1 TR000371), awarded to the University of Texas Health Science Centre at Houston in 2012 by the National Centre for Clinical and Translational Sciences.

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Table Legend

Table 1:

Title: EBL by different categories of MAP average during Surgery

Abbreviations:

N: number of patients

Q1: 1st quartile

Q3: 3rd quartile

Table 2:

Title: Results from multivariate regression analysis to assess the relationship between EBL and independent factors.

* EBL was considered as dependent variable after logarithmic transformation

Figure Legend

Figure 1:

Title: Boxplot of EBL by MAP average during surgery

Description: Box-and-whisker plot of EBL by three categories of MAP average during Surgery. The line represents the median. The bottom of box represents the 25^{th} percentile. The top of box represents the 75th percentile. T bars extend to 1.5 times height of box. Circles represent outliers.

Abbreviations:

EBL - Estimated Blood Loss

MAP - Mean Arterial Pressur