Predictors for postoperative cranial nerve complications in carotid body tumor resection: a retrospective cohort study

Alimohamad, H.; Yilmaz, D.; Mheen, P.J. van de; Jansen, J.; Hamming, J.F.; Schepers, A.

Retrospective Cohort Study

INTERNATIONAL JOURNAL OF SURGERY

OPEN

Predictors for postoperative cranial nerve complications in carotid body tumor resection: a retrospective cohort study

Hoda Alimohamad, MD[a], Dilek Yilmaz, MD[a], Perla J. Marang-van de Mheen, PhD[b], Jeroen Jansen, MD, PhD[c,a], Jaap F. Hamming, MD, PhD[a], Abbey Schepers, MD, PhD[a,*]

Introduction: Carotid body tumors (CBTs) are slow-growing benign tumors. Therefore, surgical resection is considered in case of tumor growth. The timing of surgery is of the utmost importance as the risk of iatrogenic surgical complications increases when resecting larger tumors, whereas on the other hand, resections for asymptomatic small CBT should be prevented. The primary aim of this study was to identify which tumor size or dimension is most accurate to predict nerve injury in patients undergoing resection of a CBT.

Material and methods: This retrospective cohort study included patients who underwent surgical resection of CBT at the university hospital in South-Holland. Baseline patient characteristics and tumor measurements were retrieved from the medical records. The authors assessed how the different methods of measuring the size of the tumor were interrelated using Pearson correlation. Logistic regression was used to assess which variables were independently associated with nerve injury, including age at surgery, Shamblin classification, and those dimensions that captured different aspects of tumor size (rather than measuring the same as shown by high correlations) as possible independent variables.

Results: In 125 patients, 143 CBTs were resected whereof in 35 cases cranial nerve injury occurred, (transient in 16 cases and permanent in 19 cases). The risks for nerve injury increased with larger tumor size and the Shamblin classification. Logistic regression analysis showed that the anterior-posterior (AP) diameter significantly increased the odds of a nerve injury, a doubling for every 1 cm increase in AP diameter [odds ratio (95% CI) 2.12 (1.29–3.48), $P = 0.003$].

Conclusion: This study shows that measured tumor size in the AP plane is a strong predictor for postoperative nerve injury of a CBT resection. This predictor can be used in the daily clinic to give insight in operative risks. More research is needed in order to select the most appropriate time window for CBT resection.

Keywords: carotid body tumors, cranial nerve injury, surgery

Introduction

Carotid body tumors (CBT) are rare paragangliomas located in the carotid bifurcation and are slow-growing, mostly benign tumors. Often the patients present with an indolent neck mass, but a substantial percentage nowadays is diagnosed presymptomatically after genetic counseling. These characteristics allow to monitor the natural course of the tumor, as in most patients surgical removal is not required at the time of diagnosis[1–3]. Three treatment strategies can be followed: wait and scan, surgical resection, and radiotherapy[4]. Tumor size is a determining factor in deciding for surgery because surgical resection is not required in small tumors and related with severe iatrogenic morbidity in large tumors. Resection should therefore be considered when the tumor grows and the timing of surgery is of the utmost importance. Radiotherapy can be an option in case of a large or fast-growing tumors when surgery is not an option because of local advancement

HIGHLIGHTS

- This study shows that tumor size in the anterior-posterior plane is an independent predictor for postoperative nerve injury, with the odds of nerve injury doubled for every 1 cm increase in diameter.
- The anterior-posterior plane can be used in clinical care to give insight in operative risks and it can also be used to monitor the natural course of the tumor.
- This might be a step forward in order to select the most appropriate time window to undergo surgical resection of carotid body tumors with the most benefits and lowest risk of nerve injury.

[a]Department of Surgery, [b]Department of Biomedical Data Sciences and [c]Department of Otolaryngology, Leiden University Medical Center, Leiden, The Netherlands

Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

*Corresponding author. Address: Department of Surgery, Leiden University Medical Centre, Albinusdreef 2, 2333 ZA Leiden, P.O. Box 9600, 2300 RC Leiden, The Netherlands. Tel.: +31 (0)715264005. E-mail: A.Schepers@lumc.nl (A. Schepers).

International Journal of Surgery (2023) 109:4057–4061

Received 13 April 2023; Accepted 8 August 2023

Supplemental Digital Content is available for this article. Direct URL citations are provided in the HTML and PDF versions of this article on the journal's website, www.lww.com/international-journal-of-surgery.

Published online 15 September 2023

http://dx.doi.org/10.1097/JS9.0000000000000689

or concomitant disease. It is recommended to use MRI of the head and neck area biannually or annually to objectively assess the growth of present tumors and to detect any new paraganglioma[4–6].

However, it is still debated which dimensions of tumor size are best used to predict the occurrence of surgical complications. There are multiple scoring systems that correlate the characteristics of the tumor with the risk of nerve injury[7,8]. The Shamblin classification was the first to describe the relationship between CBT and carotid arteries by indicating the degree to which the CBT is wrapped around the artery and is known for its relationship risks like bleeding during surgery[5,9–11]. Although many studies show that CBT of higher Shamblin classification have higher risk of (postoperative) nerve injury and therefore the Shamblin classification could be used as a positive predictor[10,12–18], this alone might not be the only relevant variable to predict nerve injury. Shamblin states that in their series of resections, the tumor-vessel wall relationship was variable and not always related to tumor size, but he did mention a linear relationship between the tumor size and the Shamblin groups[11]. In addition to Shamblin classifications, there are other dimensions with regard to tumor that can be taken from the MRI, which may provide additional information on growth and the potential difficulty of surgery in terms of perioperative vascular- and nerve injury[7,8]. It is currently unknown which of these possible dimensions or combination of dimensions give the best prediction of nerve injury risk. The aim of this study is therefore is to explore which tumor dimensions are best to predict postoperative nerve injury.

Material and methods

Patient selection and data collection

This retrospective study included all patients aged 18 years of older who underwent surgical resection of CBT at the university hospital in South-Holland in the Netherlands, between 1992 and 2020. Our institution is a tertiary referral center performing 5–8 surgical resections annually. As can be expected for such a long study period, the vascular surgeons changed during the years. The resections are currently performed by two dedicated vascular surgeons with special expertise in the field of head and neck surgery. Postoperatively, patients receive care at the Post Anesthesia Care Unit for one day. Since the introduction of the craniocaudal (CC) approach in 1992, it is the surgical technique of choice in our institution as it limits blood loss and facilitates safe CBT resection. What stands out the most is an early-stage ligation of the vascular supply, which reduces the tension on the tumor and facilitates a clear surgical field, giving the opportunity to recognize and preserve the neurological structures. A more detailed description of this CC dissection technique has been described previously[12]. The following baseline patient characteristics and tumor measurements were retrospectively retrieved from the medical records: sex, age, tumor size, Shamblin classification, bilateral or unilateral tumors, and the presence of other head and neck tumors. The latest MRI scan before the surgical resection was used to assess the largest diameter (cm) of the tumor in the axial plane measure in anterior-posterior (AP), followed by the largest diameter perpendicular to the axial plane measured from left-right (LR) and the CC diameter. Furthermore, there is no substantial between-observer variation for tumor detection was present which is investigated by van den Berg *et al.*[19]. The tumor volume was calculated using the linear dimension assuming that tumors have an ellipsoid shape[9]. The following equation was used: Volume (V) = 4/3 π (½AP × ½LR × ½CC).

Each surgical resection is considered as one case since there are patients whom had bilateral resection and got a surgical resection twice. The CC dissection technique was used as it limits blood loss and facilitates a safe CBT resection[12,13]. The primary outcome was nerve injury, defined as postoperative nerve impairment, which was reported by physicians as a postoperative complication during routine clinical practice, collected in the complication registry, which has previously been shown to be valid compared with record review[20,21]. Other variables were collected from patient records. A Declaration of no objection has been obtained by the ethics committees of the hospital and this study protocol was approved by the research committee. The METC LDD has reviewed the study protocol and stated that this study does not fall within the scope of the Medical Research Involving Human Subjects Act, as it does not constitute scientific research as referred to in Article 1(1)(b) of the WMO. This retrospective study was registered in the Research Registry. This paper is reported in line with strengthening the reporting of cohort, cross-sectional, and case–control studies in surgery (STROCSS) criteria[22] (Supplemental Digital Content 1, http://links.lww.com/JS9/B12).

Missing values

Multiple imputation was performed for missing data, after analyzing the missing data pattern. Out of 143 cases, 12 cases (8,4%) were incomplete and 2,4% of all values were missing. The values were missing in a random pattern, so that MCMC (Markov Chain Monte Carlo) and predictive mean matching was used for a number of 20 imputations. All characteristics and the outcome were used as predictors, but only tumor size and Shamblin classification were imputed. There were 20 datasets created with imputed data for missing values. For each analysis, the pooled data was used.

Statistical analysis

First, patient and tumor characteristics at baseline were described using the mean (SD) or median [interquartile range (IQR)] for continuous variables, depending on whether they were normally distributed or not. Dichotomous and categorical data are expressed as numbers and percentages. Secondly, we assessed how the different methods of measuring the size of the tumor were interrelated using Pearson correlation, to ensure that measurements would capture different aspects and thereby add to the prediction of nerve injury risk. Logistic regression was then used to assess which tumor dimensions were independently associated with nerve injury, adjusted for age at the time of surgery as increasing age is correlated with higher general surgical risks and tumor size (having had more opportunity to grow). The following tumor dimensions were considered as possible independent variables: the largest axial plane, the largest CC plane, the largest size in axial plane or perpendicular to axial plane, tumor volume, and Shamblin classification. We checked for multicollinearity based on the results from the Pearson correlation, with the least related variables entered first in the logistic regression model, and tested whether adding/removing a variable from the logistic regression would considerably change other coefficients. Model

fit was assessed using the Nagelkerke *R*-squared. The coefficients from the best-performing model were used to calculate the nerve injury risks for specific patients for illustrative purposes. A *P*-value of <0.05 was considered significant in all analyses. The statistical software program SPSS 26.0 (IBM) was to perform the analyses.

Results

Demographics

A total of 128 patients were included, of whom 51 patients were male, who underwent surgical resection of 143 tumors (Table 1). The median age was 41 years (IQR 32–49). Sixty-three (49.2%) patients had bilateral CBT but only 15 patients had bilateral surgical resection. No patients were considered to have a 'hostile neck' (previous radiotherapy, severely impaired neck mobility or previous extensive neck surgery). A histological examination was performed for all cases. The histology of the cases with permanent nerve injury did not show ingrowth of nerve into the tumor nor on the macroscopic level or microscopic level. Pathology confirms typical features consistent with benign paraganglioma. In only seven cases, the tumor was found to be malignant. In 52 patients, there was the presence of other head and neck paragangliomas. With regard to the tumors resected, the median value of the maximum diameter in the axial plane was 2.5 cm (IQR 2 cm–3.1 cm) and the median tumor volume was 8.35 cm^3 (IQR 4.97 cm^3–15.71 cm^3) (Table 2). Out of 143 tumors, 28 tumors were classified as Shamblin I (SH-I), 65 tumors as Shamblin II (SH-II), and 49 tumors as Shamblin III (SH-III). One tumor was not classified, because of one plane missing and no radiology report available (Table 2).

Operative outcomes

Out of 143 surgical resections, 35 cases had a cranial nerve injury, which was transient in 16 cases and permanent in 19 cases. The most commonly affected nerve was the marginal branch of the facial nerve ($N=16$) of which 13 injuries were transient and the vagus nerve ($N=11$) of which two injuries were transient. Other transient nerve injuries were the hypoglossal nerve ($N=5$) superior laryngeal nerve ($N=1$). The median recovery time for transient nerve injury was 6 months IQR (1–7 months).

A venous interposition in the carotid artery was needed in nine cases and postoperative hemorrhage occurred in seven cases (Table 2). As expected, the operative outcome showed that SH-I has the lowest nerve injury risk (3.6%), mean tumor size was 1.7 cm in the axial plane and 2.3 cm in the CC plane and the volume was 4.2 cm^3 (Table 3). With a higher Shamblin classification, consistently larger mean diameters and higher volume was shown as well as a higher nerve injury risk up to 38.8% for SH-III, with a mean maximal tumor diameter of 3.4 in the axial and 4.2 in the CC plane and a volume of 32.2 cm^3.

Table 1

Baseline patient characteristics.

Patient characteristics	$N=128$
Male sex	51 (39.8%)
Age, years, mean	51 ± 13.8
Unilateral CBT	65 (50.8%)
Bilateral CBT	63 (49.2%)
Presence of other concurrent head-neck paragangliomas	
Vagal body tumor	29 (22.6%)
Glomus jugulare tumor	9 (5.5%)
Tympanic paraganglioma	3 (3.1%)
Multiple types of head and neck paraganglioma	13 (10.9%)
Bilateral resections	15 (11.7%)

CBT, carotid body tumor; IQR, interquartile range.

Table 2

Tumor measurements and operative outcome.

Tumor measurement	$N=143$
Maximum diameter axial plane CBT (cm), mean	2.5 ± 1.2
Shamblin classification	
I	28 (19.5%)
II	65 (45.5%)
III	49 (34.2%)
Missing value	1 (0.7%)
CBT volume (cm^3), mean	17 ± 40.2
Operative outcome	
Nerve injury	35 (24.5%)
Interposition	9 (6.3%)
Postoperative hemorrhage	7 (6.8)

CBT, carotid body tumor.

Relations between tumor measurements

Pearson correlations showed that the diameters in the largest diameter (AP-LR), AP, and LR were highly correlated whereas correlations were lower with the CC plane and tumor volume and were mostly lower with Shamblin classification, sex, and age (Table 4). Logistic regression analysis showed that the AP plane significantly increased the odds of a nerve injury, a doubling for every 1 cm increase in the AP plane (odds ratio) (95% CI) 2.12 (1.29–3.48), $P=0.003$ while age and Shamblin classifications were not independently associated with nerve injury risk (Table 5). This model fitted the data better than when a different variable to measure tumor size was included (see appendix, Supplemental Digital Content 2, http://links.lww.com/JS9/B13).

Using this model, for example, a 50-year-old patient with Shamblin I and a tumor size in the AP plane of 1 cm has an expected 10.7% risk of nerve injury. Looking at the same case when the tumor would have grown to 2 cm, the risk of nerve

Table 3

Outcome and tumor characteristics by Shamblin classification.

Variables	Shamblin 1	Shamblin 2	Shamblin 3
Mean maximal diameter axial plane (cm)	1.73 ± 0.55	2.62 ± 0.80	3.42 ± 1.60
Mean maximal diameter craniocaudal plane (cm)	2.31 ± 0.84	3.23 ± 1.08	4.19 ± 1.79
Mean volume (cm^3)	4.24 ± 4.43	11.26 ± 9.98	32.24 ± 65.26
Nerve injury, *n*/*N* (%)	3.6% (1/28)	23.1% (15/50)	38.8% (19/64)
Facial nerve	0	6	5
Hypoglossal nerve	1	1	2
Vagus nerve	0	3	5
Superior laryngeal nerve	0	2	2
Multiple nerve injury	0	3	5
Temporary	1	10	12
Permanent	0	8	12

Table 4

Pearson correlation test.

Variables	Sex	Age	AP	LR	CC	LD AP-LR	V	Shamblin
Sex	1	−0.111	−0.153	−0.181	−0.028	−0.174	−0.133	0.174
Age	−0.111	1	0.044	0.095	0.065	0.033	0.064	−0.042
AP	−0.153	0.044	1	0.725	0.692	0.933	0.716	0.455
LR	−0.181	0.095	0.725	1	0.720	0.855	0.752	0.450
CC	−0.028	0.065	0.692	0.720	1	0.668	0.712	0.462
LD AP-LR	−0.174	0.033	0.933	0.855	0.668	1	0.702	0.476
V	−0.133	0.064	0.716	0.752	0.712	0.702	1	0.261
Shamblin	0.174	−0.042	0.455	0.450	0.462	0.476	0.261	1

A-P, anterior-posterior; CC, craniocaudal; LR, Left-right; LD AP-LR, largest diameter anterior-posterior; LR; left-right; V, volume.

injury as predicted with this model increases to 20.3%. However, an external validation is necessary before this can be routinely applied in clinical practice.

Discussion

This study showed that in CBT diameters in largest diameter (AP-LR), AP and LR were highly correlated but correlations were lower with the CC plane and tumor volume. Furthermore, it showed that tumor size in the AP plane is an independent predictor for postoperative nerve injury, with the odds of nerve injury doubled for every 1 cm increase in diameter. This predictor can be easily used in daily clinics in the wait and scan policy to follow up on the relation between the nerve and tumor size and to estimate the risks of nerve injury preoperatively. Shamblin classification and age were not independently associated with postoperative nerve injury. The total persisted cranial nerve damage (CND) rate was 13,9% which is lower than reported in previous literature. Despite its rarity, this is one of the largest series of surgical resections with a low complication rate, making it difficult to draw a firm conclusion.

Previous studies have shown that the risks of nerve injury increased along with the Shamblin classification. Lim J-Y *et al.*[16] reviewed surgical outcomes and complications according to the Shamblin classification and showed that Shamblin III has by far the highest risk of postoperative neurovascular complications. The present study also showed higher nerve injury risk for a higher Shamblin classification but also that when adjusted for tumor size in the AP plane, the Shamblin classification no longer was an independent predictor. Therefore, the AP diameter may be a better predictor to gage the likelihood of a nerve injury.

Kim *et al.*[7] introduced new predictors of complications in CBT resection. They showed that the tumor distance to the base skull (DTBOS) and tumor volume are predictors for bleeding and cranial nerve complications combined with the Shamblin classification. Thus, the vertical growth of CBTs has an impact on cranial nerve preservation during surgery. When it comes to increased risk of nerve injury, they showed that every 1 cm decrease in DTBOS results in a 1.5 times higher risk of neurological complications.

In our study, tumor volume or tumor size measured in the CC plane were also analyzed in combination with the Shamblin classification to assess the risk of postoperative nerve injury. This combination was not an independent predictor for postoperative nerve injury and did not fit the data as good as the model with the AP diameter.

This study is limited by the number of included CBT resections. However, the low incidence of the tumor hampers prospective data collection in a larger series of patients. It is possible that the complications were underreported, however, this is not likely since we have a solid complication registration since 1970 and which is legally required from 1996. Furthermore, the retrospective data collection from medical records and routinely collected complication might have led to underreporting of complications. However, a previous validation study showed that routine reporting of complications by the system that was used in this study was valid particularly for the more severe complications (like nerve injury risks). Future studies should focus on measuring AP diameter in consecutive cases, resulting in clear and detailed information on operative risks for the individual patient.

Table 5

Outcome predicting variables for cranial nerve injury.

Model 5 Variables	Coefficient	Odds ratio [95% CI]	*P*
Age (years)	−0.003	0.99 [0.96–1.03]	0.888
Shamblin category			
I	1.53	4.62 [0.55–38.40]	0.157
II	(reference)	1 (reference)	0.528
III	−0.29	0.74 [0.30–1.84]	
Anterior-posterior	0.75	2.12 [1.29–3.48]	0.003
Model fit (Nagelkerke *R*-squared)	0.263		
Constant	−4.249		
	χ^2	*P*	
Hosmer–Lemeshow test	4.47	0.812	

Conclusion

In conclusion, the largest diameter (AP-LR), AP and LR diameters are highly correlated dimensions in CBT, whereas correlations were low with diameter in the CC plane and tumor volume. Tumor size in the AP plane is an independent predictor for postoperative nerve injury whereas the Shamblin classification was not. This predictor can be used in clinical care to give insight in operative risks. The AP plane can also be used to monitor the natural course of the tumor. This might be a step forward in order to select the most appropriate time window to undergo surgical resection of CBT with the most benefits and lowest risk of nerve injury.

Ethical approval

Medical-ethical research and review commitee Leiden, Den Haag, Delft (METC LDD) Reference: h N19.108/. Research Registry. Identifying number is: researchregistry8786. https://www.researchregistry.com/browse-theregistry#home/registrationdetails/642086aa408c4a00284e03f0/.

Sources of funding

There are no fundings.

Author contribution

H.A.: study design, data collections, data analysis, and writing; D. Y.: study design, data collections, data analysis, and writing; P.J. M.-v.d.M.: study design, data collections, data analysis, and writing; J.J.: study design, data collections, data analysis, and writing; J. F.H.: study design, data collections, data analysis, and writing; A.S.: study design, data collections, data analysis, and writing.

Conflicts of interest disclosure

There are no conflicts of interest.

Guarantor

Abbey Schepers.

Data availability statement

The law GDPR/General Data Protection prohibits to share data retrieved from patients record. There is no consent of patients to share data publicly.

References

[1] Jansen JC, van den Berg R, Kuiper A, *et al*. Estimation of growth rate in patients with head and neck paragangliomas influences the treatment proposal. Cancer 2000;88:2811–6.
[2] Langerman A, Athavale SM, Rangarajan SV, *et al*. Natural history of cervical paragangliomas: outcomes of observation of 43 patients. Arch Otolaryngol Head Neck Surg 2012;138:341–5.
[3] Prasad SC, Mimoune HA, D'Orazio F, *et al*. The role of wait-and-scan and the efficacy of radiotherapy in the treatment of temporal bone paragangliomas. Otol Neurotol 2014;35:922–31.
[4] Alimohamad H, Yilmaz D, Hamming JF, *et al*. Identifying factors influencing decision making in patients diagnosed with carotid body tumors: an exploratory study. Ann Vasc Surg 2020;68:159–65.
[5] Moore MG, Netterville JL, Mendenhall WM, *et al*. Head and neck paragangliomas: an update on evaluation and management. Otolaryngol Head Neck Surg 2016;154:597–605.
[6] Heesterman BL, de Pont LMH, Verbist BM, *et al*. Age and tumor volume predict growth of carotid and vagal body paragangliomas. J Neurol Surg B Skull Base 2017;78:497–505.
[7] Kim GY, Lawrence PF, Moridzadeh RS, *et al*. New predictors of complications in carotid body tumor resection. J Vasc Surg 2017;65:1673–9.
[8] Gu G, Wu X, Ji L, *et al*. Proposed modification to the Shamblin's classification of carotid body tumors: a single-center retrospective experience of 116 tumors. Eur J Surg Oncol 2021;47:1953–60.
[9] Heesterman BL, Verbist BM, van der Mey AG, *et al*. Measurement of head and neck paragangliomas: is volumetric analysis worth the effort? A method comparison study. Clin Otolaryngol 2016;41:571–8.
[10] Mascia D, Esposito G, Ferrante A, *et al*. Carotid body tumor contemporary management in a high-volume center. J Cardiovasc Surg (Torino) 2020;61:459–66.
[11] Shamblin WR, ReMine WH, Sheps SG, *et al*. Carotid body tumor (chemodectoma). Clinicopathologic analysis of ninety cases. Am J Surg 1971;122:732–9.
[12] van der Bogt KE, Vrancken Peeters MP, van Baalen JM, *et al*. Resection of carotid body tumors: results of an evolving surgical technique. Ann Surg 2008;247:877–84.
[13] Paridaans MP, van der Bogt KE, Jansen JC, *et al*. Results from craniocaudal carotid body tumor resection: should it be the standard surgical approach? Eur J Vasc Endovasc Surg 2013;46:624–9.
[14] Dixon JL, Atkins MD, Bohannon WT, *et al*. Surgical management of carotid body tumors: a 15-year single institution experience employing an interdisciplinary approach. Proc (Bayl Univ Med Cent) 2016;29:16–20.
[15] Kunzel J, Koch M, Brase C, *et al*. Treatment of cervical paragangliomas: is surgery the only way? Am J Otolaryngol 2014;35:186–91.
[16] Lim JY, Kim J, Kim SH, *et al*. Surgical treatment of carotid body paragangliomas: outcomes and complications according to the shamblin classification. Clin Exp Otorhinolaryngol 2010;3:91–5.
[17] Robertson V, Poli F, Hobson B, *et al*. A systematic review and meta-analysis of the presentation and surgical management of patients with carotid body tumours. Eur J Vasc Endovasc Surg 2019;57:477–86.
[18] Shiga K, Katagiri K, Ikeda A, *et al*. Challenges of surgical resection of carotid body tumors - multiple feeding arteries and preoperative embolization. Anticancer Res 2022;42:645–52.
[19] van den Berg R, Schepers A, de Bruine FT, *et al*. The value of MR angiography techniques in the detection of head and neck paragangliomas. Eur J Radiol 2004;52:240–5.
[20] Marang-van de Mheen PJ, van Hanegem N, Kievit J. Effectiveness of routine reporting to identify minor and serious adverse outcomes in surgical patients. Qual Saf Health Care 2005;14:378–82.
[21] Kievit J, Krukerink M, Marang-van de Mheen PJ. Surgical adverse outcome reporting as part of routine clinical care. Qual Saf Health Care 2010;19:e20.
[22] Mathew G, Agha R. for the STROCSS Group. STROCSS 2021: strengthening the reporting of cohort, cross-sectional and case-control studies in surgery. Int J Surg 2021;96:106165.