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The Effect of the MAYO Adhesive Probability Score on Intraoperative Parameters in Laparoscopic Live Donor Nephrectomy and Bench Surgery

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What's known on the subject? and What does the study add?

In the literature, there are different scoring systems defined to predict the degree of difficulty of nephrectomy surgery. PADUA, RENAL and centrality-index scoring systems are some of them. Mayo Adhesive Probability score (MAP score) is also one of these nephrometry systems developed by Davidiuk et al. in 2014 to predict surgical difficulty using radiologic image-based measurements and interpretations. Published studies associate parameters such as intraoperative difficulty, conversion to open surgery, operation time, and estimated blood loss in laparoscopic donor nephrectomy with a high MAP score. Bench surgery is an important step in kidney transplantation. Since it is a dissection-based procedure and its complications can directly affect the success of kidney transplantation, it is important to predict the degree of difficulty in advance. This is the first study in the literature investigating the effect of MAP score on bench surgery parameters in kidney transplantation. In this respect, it contributes to the existing knowledge on laparoscopic donor nephrectomy and presents new point of view on bench surgery.

Abstract

Objective: Mayo Adhesive Probability score (MAP score) is a nephrometry system to predict surgical difficulty using radiologic image-based measurements and interpretations. MAP score is based on two main factors: Perinephric fat thickness at the level of the renal vein and perinephric fat stranding, which was defined as a linear area of soft tissue attenuation in the perinephric space. This study evaluated the efficacy of the MAP score on intraoperative parameters of laparoscopic donor nefrectomy and bench surgery.

Materials and Methods: Four hundred twenty-one laparoscopic live-donor nephrectomies (LDN) and subsequent bench surgeries carried out between 2016 and 2022 have been included in this study. Preoperative computerized tomography images of donors were blindly scored for determination of MAP scores. Sex, age, hypertension, cigarette smoking, dyslipidemia, and body mass index (BMI) were evaluated as risk factors for high MAPS.

Results: In females and males, the percentage of donors in the high MAPS group was 11.79% and 25.32%, respectively, and the difference between the two groups is statistically significant. Similarly, the percentage of donors in the high MAPS group is higher in smokers (42.57%) compared to non-smokers (8.75%) ($p<0.05$).

Conclusion: Although a high MAP score can lead to longer operative time both in LDN and bench surgery, complications in LDN and bench surgery do not seem to be affected by a high MAP score.

Keywords: Kidney, transplantation, live donor nephrectomy, bench surgery, MAP score

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Introduction

The most common technique used for organ retrieval in kidney transplantation is laparoscopic live-donor nephrectomy (LDN) (1). It has succeeded over open donor nephrectomy with decreased morbidity, less postoperative pain, shorter hospital stay, and a shorter time to return to social and professional life while achieving similar outcomes in terms of graft function and survival rates (2,3). Kidneys retrieved laparoscopically from live donors also have shown better results compared to kidneys from deceased donors (4). On the other hand, LDN is a technically challenging operation that may require training and experience in laparoscopic surgery (5). A factor that may contribute to these difficulties is the presence of thick and sticky inflammatory fat tissue surrounding the kidneys, which is defined as adherent perinephric fat (APF). In previous studies evaluating difficulty in partial nephrectomies, a positive correlation was found between the presence of APF and operative time, a higher risk for conversion to open surgery, surgical difficulty, and blood loss during surgery (6,7).

Different renal morphometry systems have been developed to predict surgical difficulty in partial nephrectomy, including Preoperative Aspects and Dimensions Used for Anatomical classification (PADUA) score, Radius Endophytic/exophytic Nearness Anterior posterior Location (RENAL) score and Centrality-index score (8-10). Mayo Adhesive Probability score (MAP score) was also one of these nephrometry systems developed by Davidiuk et al. (11) in 2014 to predict surgical difficulty using radiologic image-based measurements and interpretations. MAP score (MAPS) is based on two main factors: Perinephric fat thickness at the level of renal vein and perinephric fat stranding, which was defined as a linear area of soft tissue attenuation in the perinephric space (Figure 1). Stranding is speculated to be indicative of underlying metabolic and inflammatory processes

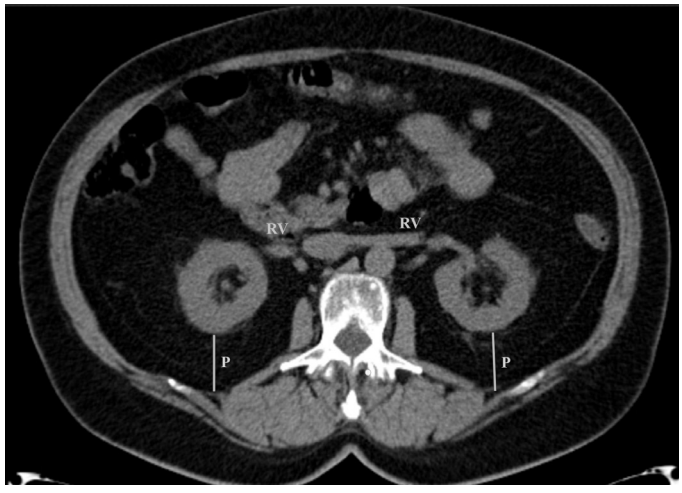

Figure 1. Perinephric stranding and fat measurements at the level of the renal vein

(12). The sum of points taken from these two factors forms the MAP score ranging from 0 to 5. Previous studies have revealed the effectiveness of MAP score in predicting the presence of APF and a high MAP score is associated with longer operative time and increased complications in laparoscopic and robot-assisted partial nephrectomy series (13-16). Intraoperative difficulty, conversion to open surgery, operative time, and estimated blood loss have also been associated with high MAP scores in laparoscopic donor nephrectomy (17-19).

To minimizing ischemia time in live-donor kidney transplantation, coordination of donor and recipient operations is of paramount importance. Thus, the prediction of operative time for donor and bench surgery helps in determining when the recipient operation should be initiated. As the presence and severity of APF is a factor that can affect operative times, its prediction using MAP score may aid efforts to minimize warm ischemia time.

To our knowledge, this study is novel in evaluating the efficacy of MAP score on bench surgery operative time and complications, which was facilitated by recording of operative data during bench surgery. In this study, we retrospectively analyzed the effect of MAP score on intraoperative parameters in LDN and bench surgery.

Materials and Methods

This study complies with the Declaration of Helsinki and was performed by institutional approval from İstanbul Gelişim University Ethics Committee (approval no: 2023-01-32). Four hundred twenty-one laparoscopic live-donor nephrectomies and subsequent bench surgeries that have been carried out between 2016 and 2022 have been included in this study. All of the laparoscopic donor nephrectomies were performed by one senior surgeon (MA) and all bench surgeries were performed by one senior transplant surgeon (SA). Laparoscopic donor nephrectomies were performed transperitoneally with three 5 mm trocars and a 12 mm trochar placed in the Pfannenstiel incision, which is prepared at the beginning of surgery and temporarily sutured until organ extraction. LDN is performed using the dissection plane outside Gerota's fascia as in radical nephrectomy. The renal artery and vein are controlled by separate Endo-GIA staplers (Covidien, Medtronic Inc., USA) and ureter using Hem-O-Lok polymer clips (Weck Surgical Instruments, Teleflex Medical, Durham, NC, USA). At the end of the surgery, no surgical drains were placed in any patient. Intraoperative complication data were extracted from operation notes in the patient charts. After extraction, the kidneys were perfused by Custodiol (histidine-tryptophan ketoglutarate) solution. Kidneys were then skeletonized over the capsule, all of perinephric fat and lymphatics were dissected, and all perihilar lymphatics

were ligated to avoid lymphoceles. Bench surgery data were collected and recorded by a kidney transplantation coordinator. Preoperative computerized tomography images of donors were blindly scored for determination of MAP scores (Table 1). Zero-two MAPS are accepted as low and ≥3 MAPS are accepted as high. Sex, age, hypertension, cigarette smoking, dyslipidemia and body mass index (BMI) were evaluated as risk factors for high MAPS. Diabetes mellitus was excluded due to the low number of donors. Laparoscopic donor nephrectomy complications were classified according to Clavien-Dindo system.

Statistical Analysis

Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS), version 25.0 (IBM Corporation, Armonk, NY, USA). Formalities of distributions for continuous variables were checked by histogram graphics and Kolmogorov-Smirnov test. In the presentation of descriptive analyses, mean, standard deviation, median, minimum, and maximum values have been used. In normally distributed variables, results were presented as mean ± standard deviation. For categorical variables, results were presented as count and percentage. Categorical variables were compared with the chi-square test. Mann-Whitney U test was used for mean univariate differences in ordinal variables and for continuous variables that were not normally distributed. Metric data were compared using Spearman's correlation test. Multivariate analyses for factors affecting MAP scores were performed by binary logistic regression analysis. Factors affecting operative time and bench time were evaluated by linear regression analysis. P values less than 0.05 were considered statistically significant.

Results

A total of 421 donors who had laparoscopic donor nephrectomy and whose grafts subsequently underwent bench surgery were enrolled in this retrospective study. The mean age of the donors was 48.92±13.31. Two hundred and sixty-three (62.47%) donors were female and 158 (37.53%) of the donor were male. The mean BMI of the donors was 27.46±5.35 kg/m^2. Forty-one (9.74%) donors were operated on the right side, and the remaining 380 (90.26%) donors were operated on the left side. One hundred and one (23.99%) donors were cigarette smokers and 320 (76.00%) of them were non-smokers. The number of donors who had dyslipidemia and hypertension was 109 (25.89%) and 45 (10.68%), respectively (Table 2).

Table 1. Mayo Adhesive Probability score algorithm

		Points
Posterior perinephric fat thickness (cm)	<1 cm	0
	1.0-1.9	1
	≥2.0	2
Stranding	None	0
	Type 1	2
	Type 2	3

Mean MAP scores in relation to sex, cigarette smoking, laterality, presence of hypertension, dyslipidemia, and multiple arteries are given in Table 3. Mean MAPS in female and male donors were 0.78±1.28 and 1.3±1.56, respectively and the difference was statistically significant ($p<0.05$). Mean MAPS in smokers were 1.37±1.73 whereas mean MAPS in non-smokers were calculated as 0.73±1.2 and the difference was statistically significant ($p<0.05$). There were no significant differences in mean MAPS in relation to laterality, presence of hypertension, and multiple arteries ($p>0.05$).

Patients who had a MAP score of 0-2 were accepted as the Low MAPS group, whereas donors with MAP score of 3-5 were accepted as the High MAPS group. Three hundred and fifty (83.13%) donors had a MAP score <2 and 71 (16.86%) had a MAP score ≥3. In females and males, the percentage of donors in the high MAPS group is 11.79% and 25.32%, respectively and the difference between two groups is statistically significant. Similarly, the percentage of donors in the high MAPS group is higher in smokers (42.57%) compared to non-smokers (8.75%) ($p<0.05$). The percentage of patients in the high MAPS group in relation to laterality, presence of dyslipidemia, hypertension, and multiple arteries is given in Table 4.

Mean age in the low and high MAPS groups were 49.1±16.8 and 56.2±18.1 respectively and the difference between the groups were statistically significant. Mean BMI in the low MAPS group was 26.3±5.3 and mean BMI in high MAPS group was 28.28±5.6. The difference was statistically significant ($p<0.05$) (Table 5). Correlation of MAPS with age and BMI was evaluated with Spearman's correlation test and a correlation in the same

Table 2. Descriptive data

Age (Mean ± SD)		48.92±13.31
Sex (n, %)	Female	263(62.47)
	Male	158 (37.53)
Body mass index (Mean ± SD)		27.46±5.35
Laterality (n, %)	Right	41 (9.74)
	Left	380 (90.26)
Smoking (n, %)	No	320 (76.00)
	Yes	101 (23.99)
Dyslipidemia (n, %)	No	312 (74.10)
	Yes	109 (25.89)
Hypertension (n, %)	No	376 (89.31)
	Yes	45 (10.68)

SD: Standard deviation

direction was found between MAPS and age, as well as BMI (r=0.155 and 0.118, respectively).

Mean operative time in the low MAPS and high MAPS groups was 72.53±10.52 min and 80.72±12.21 min, respectively and the difference was statistically significant. Mean bench time in the low MAPS group was 42.02±6.81 and mean bench time in the high MAPS group was 48.27±8.18. The difference between the groups was statistically significant (p<0.001) (Table 6).

Binary logistic regression analysis was performed to evaluate risk factors for the high MAPS group. Each year increase in

Table 3. MAP score by parameters

Mean ± SD		MAP score		p-value
		Median (Min-Max)		
Sex	Male	1.3±1.56	1 (0-5)	**<0.05**
	Female	0.78±1.28	0 (0-5)	
Cigarette smoking	No	0.73±1.2	0 (0-5)	**<0.05**
	Yes	1.37±1.73	1 (0-5)	
Laterality	Right	0.73±1.36	0 (0-5)	0.158
	Left	1±1.42	0 (0-5)	
Hypertension	No	1±1.44	0 (0-5)	0.455
	Yes	0.78±1.15	0 (0-3)	
Dyslipidemia	No	0.95±1.37	0 (0-5)	0.581
	Yes	1.05±1.53	0 (0-5)	
Multiple arteries	No	0.94±1.41	0 (0-5)	0.271
	Yes	1.08±1.44	0 (0-5)	

SD: Standard deviation, Mann-Whitney U test, MAP score: Mayo Adhesive Probability score, Min: Minimum, Max: Maximum

Table 4. Number of patients in MAPS groups

		MAPS				p-value
		Low (0-2)		High (3-5)		
		n	%	n	%	
Sex	Male	118	(74.68)	40	(25.32)	**<0.05**
	Female	232	(88.21)	31	(11.79)	
Cigarette smoking	No	292	(91.25)	28	(8.75)	**<0.05**
	Yes	58	(57.43)	43	(42.57)	
Laterality	Right	35	(85.37)	6	(14.63)	0.688
	Left	315	(82.89)	65	(17.11)	
Hypertension	No	312	(82.98)	64	(17.02)	0.804
	Yes	38	(84.44)	7	(15.56)	
Dyslipidemia	No	261	(83.60)	51	(16.40)	0.668
	Yes	89	(81.82)	20	(18.18)	
Multiple arteries	No	269	(83.85)	52	(16.15)	0.479
	Yes	81	(80.81)	19	(19.19)	

chi-square test, MAPS: Mayo Adhesive Probability score

Table 5. Age and BMI in MAPS groups

	MAPS				p-value
	Low (0-2)		High (3-5)		
	Mean ± SD	Median (Min-Max)	Mean ± SD	Median (Min-Max)	
Age	47.78±13	48 (15-81)	54.56±13.48	55 (25-83)	**<0.001**
BMI	26.3±5.3	27 (17-42)	28.28±5.6	28 (18-40)	**<0.05**

Mann-Whitney U test, BMI: Body mass index, Min: Minimum, Max: Maximum, MAPS: Mayo Adhesive Probability score, BMI: Body mass index, SD: Standard deviation

age increases the risk of having a high MAPS score by 1.051 and male sex increases the risk of having a high MAPS by 2.69 compared to female sex. The risk increase by BMI and cigarette smoking is presented in Table 7.

Five (1.18%) Clavien-Dindo classification grade 2 or above complications included blood transfusion, paralytic ileus, chylous ascites treated medically, chylous ascites treated surgically, and splenectomy with pancreatic leak. The MAP scores of donors whom encountered these complications are given in Table 8. In bench surgery there were 2 complications, both of which were injury to segmental arteries and they were reconstructed meticulously. One of these donors had a MAP score of 2, whereas the other had a score of 3, which was statistically insignificant (p>0.05).

Discussion

MAPS is a score that allows numerical expression of the presence and adhesion severity of perinephric fat by measurements and interpretations made on radiological imaging. It was first defined by Davidiuk et al. (11) in robotic partial nephrectomy operations to evaluate the adhesion severity of perinephric adipose tissue and thus to predict intraoperative parameters and surgical difficulty. It has been shown that as this score ranging between 0 and 5 increases, the perinephric adipose tissue is thicker and has a more adhesive structure. Using this score, the presence of APF can be predicted in the preoperative period (11). There are other studies in the literature confirming the efficacy of MAP score in predicting intraoperative parameters (operation time, specifically) in laparoscopic and robot -assisted partial nephrectomy series (20). In one of these studies conducted with 311 Robot Assisted Partial Nephrectomy (RAPN) patients by Ishiyama et al. (14), RAPN surgery was evaluated in 2 parts: Dissection and resection. It was shown that the dissection time was significantly prolonged in patients when MAPS was higher than 3.

After the definition of the MAP score, the predictive capacity of this score was evaluated not only in robotic partial nephrectomy operations but also in other renal surgery modalities. In their study of 215 patients who underwent laparoscopic partial nephrectomy (LPN), Fang et al. (21) stated that the presence of APF was associated with longer operation and warm ischemia time and more estimated blood loss, and emphasized that the only independent variable indicating APF was MAPS. Similarly,

Table 6. Operative and bench time in MAPS groups

	MAPS				p
	Low (0-2)		High (3-5)		
	Mean ± SD	Median (Min-Max)	Mean ± SD	Median (Min-Max)	
Operative time	72.53±10.52	71 (45-110)	80.72±12.21	80 (60-120)	**<0.001**
Bench time	42.02±6.81	40 (25-70)	48.27±8.18	45 (30-70)	**<0.001**

Mann-Whitney U test, MAPS: Mayo Adhesive Probability score, SD: Standard deviation, Min: Minimum, Max: Maximum

Table 7. Regression analysis of risk factors

MAPS	B	S.E.	p	Exp (B)	95% CI for Exp (B)	
					Lower	Upper
Age	0.050	0.012	**<0.001**	1.051	1.027	1.075
BMI	0.296	0.132	**0.001**	1.171	1.018	1.216
Male sex	0.985	0.300	**0.001**	2.679	1.488	4.823
Cigarette smoking	2.100	0.402	**<0.001**	6.164	4.517	14.753

Binary Logistic Regression Analysis, BMI: Body mass index, MAPS: Mayo Adhesive Probability score, CI: Confidence interval

Table 8. LDN complications by MAPS groups

Clavien-Dindo classification	Number of complications	Complication	Low MAPS (n=350)	High MAPS (n=71)	p-value
Grade 2	3	Blood transfusion	1 (0.28%)	0	0.216
		Paralytic ileus	1 (0.28%)	0	0.216
		Chylous ascites - Medical	0	1 (1.40%)	0.067
Grade 3	2	Chylous ascites - Surgery	1 (0.28%)		0.216
		Splenectomy and pancreatic leak	1 (0.28%)		0.216

LDN: Laparosacopic donor nephrectomy, MAPS: Mayo Adhesive Probability score

Yao et al. (13) reported that patients with MAPS ≥3 had longer dissection time and higher estimated blood loss in their LPN series of 318 patients. In another study, Sempels et al. (20) evaluated the PADUA, RENAL, arterial-based complexity (ABC) score, and MAP scoring systems in partial nephrectomy patients and stated that among these scoring systems, MAPS was the only scoring system that predicted serious surgical complications as well as longer operation time. After a review by Lee et al. (22), usage of MAP score has gained wider acceptance due to its ability to predict the presence of APF and to give information that can guide preoperative planning and patient assessment.

The efficacy of the MAP score in predicting APF in the partial nephrectomy series has led to the interest of using this score in the prediction of surgical parameters in laparoscopic donor nephrectomy operations. With the fact that donors are selected from healthy individuals for living kidney donation, being able to predict intraoperative parameters was more of concern to increasing patient safety. In their study evaluating the effect of the MAP score on LDN parameters, Sato et al. (18) evaluated renal transplantation results from 782 living donors. Although no significant effect was observed on surgical complications and postoperative graft functions, a higher MAP score resulted in a longer operation time and increased estimated blood loss. In the same study, age, male gender, high BMI and presence of hypertension, hyperlipidemia and diabetes mellitus were determined as predisposing factors for a high MAP score. Similarly, Özçelik et al. (19) stated that LDN operative time was longer in patients with a MAP score ≥1 and found age, male gender and high BMI to be predictive for high MAP scores. In another study, Franquet et al. (17) stated that conversion to open surgery and Clavien-Dindo grade 3-4 complication rates were significantly higher in LDN patients with a MAP score of 3 and higher. In this study, the LDN operation time was found to be significantly longer in the group with high MAP scores. However, there was no difference in perioperative complication rates of LDN. In this sense, the presence of APF seems to complicate dissection during donor nephrectomy resulting in longer operative time, which is consistent with previous studies (17-19,23). As the dissection was performed outside Gerota's fascia in this series, increased lymphatics at the kidney hilum might have resulted in longer operative time. The overall Clavien-Dindo Grade 2 or above complication rate in this study was 1.1%, which is low compared to similar studies. Franquet et al. (17) reported 16% intraoperative difficulties, which lead to 4.2% conversion to open surgery, and Sato et al. (18) reported 2.4% complications according to the classification proposed by Kocak et al. (24). The low number of complications in this study can be attributed to the experience of the team in a high -volume center and it mighy be postulated that few number and percentage of complications might have affected the statistical analysis. With the current increased bleeding control capacity of endoscopic surgical instruments and sealing devices used for dissection, and possibly with surgical experience, the difficulty associated with the presence of APF appears to be eliminated without a significant increase in complication rates. Blood loss is another parameter commonly used in describing operative difficulty. At our center, due to very low blood loss, which is usually less than 50 cc, it has not been recorded as an operative parameter since 2015 and has not been mentioned in this retrospective analysis.

When the determining risk factors for a high MAP score in this study, age, high BMI, male gender and smoking were significant predisposing factors in multivariate analysis, but the presence of hypertension and dyslipidemia was not found to be significant for high MAPS and similar results can be seen in the literature. As a general rule, uncontrolled hypertension and diabetes mellitus are a contraindication for kidney donation, and willing candidates can only be accepted under certain conditions (25). This makes a great impact on study groups evaluating MAPS. Studies involving patients with kidney tumors undergoing LPN will be incomparable to studies involving kidney donors in terms of hypertension and diabetes, and no data is available about diabetes in most previous studies evaluating the MAP score in patients with LDN patients (17,19,23). When the previous studies are evaluated in general, it would not be wrong to interpret that the parameters with the strongest emphasis for high MAPS are age, male gender, and high BMI. In our study, in addition to these factors, smoking is also related to high MAPS. In a study including 46 donor nephrectomies, Yanishi et al. (23) reported 44% of smokers in the high MAP score group, whereas 18.9% of the low MAP score group were smokers, but the difference was insignificant. In the literature, smoking is a widely accepted risk factor that causes inflammation by smoking-related oxidative stress (26). Also, in our clinical experience, smokers are a group of patients where hilar lymphatics are abundant and lymphatic dissection during LDN and bench surgery is harder and takes longer to perform.

In our study, the effect of the MAP score on surgical parameters was also evaluated for bench surgery. Bench surgery time was also significantly longer in the group with a high MAP score, but there was no difference in complications that required reconstruction. To our knowledge, this is the first data in the literature about how MAP score can affect bench surgery parameters. As there are no previous studies, it was impossible to evaluate the current results of bench surgery considering the literature. However, considering that bench surgery is essentially based on the complete removal of perinephric adipose tissue from the renal parenchyma, it is understandable that the presence of APF shown by high MAPS makes this dissection difficult and prolongs the operation time. Avoiding vascular complications that may require reconstruction may partially

depend on the experience of the surgeon, which might have resulted in the current results.

Considering this data, when the MAP score is over 3, a difficulty in LDN and bench surgery should be expected. The Surgical teams must be psychologically and technically well prepared when evaluating such donors and performing surgery. It can be recommended that donor and recipient operations may be synchronized according to the surgical team's evaluation of the MAP score.

Study Limitations

The main limitation of this stuy is its retrospective design. The data has been collected in more than 5 years, and it is possible that surgical practices might have changed in this time period and this might have affected the results. The second limitation may be in interpreting and scoring perirenal fat in terms of stranding. This is a subjective evaluation and carries the risk of interobserver differences.

Conclusion

A high MAP score has been linked to age, male gender, BMI, and cigarette smoking. While a high MAP score can lead to longer operative time both in LDN and bench surgery, complications in LDN and bench surgery do not seem to be affected by a high MAP score.

Ethics

Ethics Committee Approval: This study complies with the Declaration of Helsinki and was performed by institutional approval from İstanbul Gelişim University Ethics Committee (approval no: 2023-01-32).

Informed Consent: Retrospective study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: S.A., M.A., Concept: S.A., M.A., Design: S.A., O.A., Data Collection or Processing: S.A., O.A., Analysis or Interpretation: S.A., O.A., Literature Search: S.A., O.A., M.A., Writing: S.A., O.A.

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