Effect of Obesity on Prone Percutaneous Nephrolithotomy Outcomes: A Systemic Review

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Purpose: With decreased physical activity, growing sedentary lifestyle, and high fat diet, obesity has become a pandemic disease all over the world. In this review, we aim to assess the effect of obesity on prone percutaneous nephrolithotomy. (PNL) outcomes.

Materials and Methods: We performed a comprehensive review of the published articles in PubMed®, Medline, Scopus, Cochrane database from January 1, 2004 through June 31, 2015, using the key words; body mass index, obesity, morbid obesity, super obese, urolithiasis, nephrolithiasis, percutaneous nephrolithotomy and percutaneous lithotripsy. Original research articles published in English language with accessibility to the full text article were analyzed for our review.

Results: At the end of the evaluation, we found 12 articles in English language, analyzing the effect of obesity on prone PNL outcomes. Except one study, eleven studies were evaluated in this review had a retrospective nature without randomization. Stone free status of patients was in a wide range between 49%-90% in obese patients and 41%-90% in morbid obese patients.

Conclusion: PNL is a safe and effective treatment modality for renal stone(s) in obese and morbid obese patients. However, effect of body mass index on PNL outcomes including operation time, fluoroscopy screening time, hospitalization time, complications and stone free status are still debatable.

Keywords: kidney calculi; complications; surgery; length of stay; nephrostomy; percutaneous; adverse effects; obesity; morbid; operative time; overweight; prospective studies.

INTRODUCTION

According to World Health Organization.(WHO), obesity is described as a body mass index. (BMI) greater than or equal to 30 kg/m^2.[1] With decreased physical activity, growing sedentary lifestyle and high fat diet, prevalence of obesity has doubled over last decades and obesity has become a pandemic disease, not only in developed countries, but also all over the world.[2,3] Its well known that, obesity is associated with comorbid conditions such as diabetes mellitus, hypertension and nephrolithiasis.[4,5] Additionally, anesthetic and surgical complications are higher in obese patients when compared with normal weight patients.[6]

Percutaneous nephrolithotomy (PNL) is a preferred treatment option for renal stone(s) larger than 2 cm and staghorn calculi.[7,8] Although its' minimally invasive nature, PNL procedure has potential serious complications including; bleeding, adjacent organ injuries and urosepsis.[9,10] Moreover, in obese patients, PNL has some technical difficulties.[11] Excessive fat tissue decrease image quality of fluoroscopy screening and reduce the accuracy of defining the appropriate calyx or stone during access. Besides, identifying a landmark at the beginning of the operation is complicated in obese patients. Also, accessing to the pelvicaliceal system and dilating the tract is more challenging. Additionally, inadequate length of working sheath and working instruments in obese patients affects adversely on PNL outcomes.[12-14] In this review, we aim to assess the effect of obesity on prone PNL outcomes and try to lead the way for urologists who are planning to perform PNL on obese patients.

MATERIALS AND METHODS

Before writing this review, we performed a comprehensive PubMed®, Medline, Scopus, Cochrane database investigation of articles published from January 1, 2004 through June 31, 2015, using the key words; BMI, obesity, morbid obesity, super obese, urolithiasis, nephrolithiasis, percutaneous nephrolithotomy and percutaneous lithotripsy. All terms are in acordance with

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Table 1. Preoperative Characteristics in different study.

Studies	Body Mass Index	Patients	Mean BMI	Age, years	Male	ASA ≥ 3	Stone size(cm)	Single stone	Multiple Stones	Previous Surgery
Alyami et al.[29]	Normal (< 25)	39	NA	55	23	NA	2.3	NA	NA	17
	Overweight	24	NA	60	10	NA	2.3	NA	NA	9
	Obese (30-39)	41	NA	60	15	NA	2.2	NA	NA	19
	Morbid obese	10	NA	53	5	NA	2.4	NA	NA	4
P value				.1*	.2**		.9*			.5**
Bagrodia et al.[21]	Normal (< 25)	26	NA	58	NA	8	1.7	13	13	10
	Overweight	44	NA	54	NA	13	1.6	14	30	33
	Obese (30-39)	51	NA	53	NA	19	1.8	19	32	31
	morbid obese	29	NA	45	NA	12	2.3	11	18	18
P value				.06		.7	.61		.51	.03
Fuller et al.[22]	Normal (< 25)	1394	NA	Na	755	98	NA	581	813	NA
	Overweight	1568	NA	Na	970	108	NA	683	885	NA
	Obese (30-39)	650	NA	Na	335	123	NA	260	390	NA
	Super (≥ 40)	97	NA	Na	32	60	NA	37	60	NA
	P value				< .001	< .001		.591		
El-Assym et al.[30]	Normal (< 25)	270	NA	46.5 ± 10.9	176	Na	2.5 ± 0.8	98	172	NA
	Overweight	235	NA	47 ± 10.9	220	Na	2.5 ± 0.7	121	204	NA
	Obese (30-39)	468	NA	46.9 ± 10.5	302	Na	2.4 ± 0.8	172	296	NA
	Morbid obese	92	NA	46.5 ± 10	43	Na	2.5 ± 0.8	44	48	NA
P value				.75	.003		.76	.43		
Keheila et al.[15]	Super (≥ 50)	17	57.2	54.8	6	2.7	3.3	Na	Na	Na
	P value									
Koo et al.[23]	Normal (< 25)	65	22.1	50	35	7	NA	NA	NA	NA
	Overweight	79	27.5	56	54	13	NA	NA	NA	NA
	Obese (30-39)	67	33.8	56	55	7	NA	NA	NA	NA
	Morbid obese	12	43.9	51	6	4	NA	NA	NA	NA
P value										
Kuntz et al.[14]	Normal (< 25)	55	22.40	58	22	21	NA	18	26	NA
	Overweight	74	27.40	51	37	19	NA	23	27	NA
	Obese(30-35)	67	32	52	35	28	NA	26	31	NA
	Morbid obese	72	40.5	29	31	34	NA	23	43	NA
P value			< .001	.123	0.47	< .001		0.01		
Ortiz et al. [28]	Normal (< 25)	77	22.70	51.9 ± 15.8	40	NA	NA	70	7	10
	Overweight	93	27.30	56.2 ± 13.3	56	NA	NA	84	9	10
	Obese (30-39)	75	33.7	54.7 ± 12.1	40	NA	NA	64	11	7
	Morbid obese	10	44.1	58.4 ± 11.2	3	NA	NA	7	3	2
P value			< .01	.24	.24			.72		.1
Sergeyev et al.[16]	Normal (< 25)	15	22.65	57.93	NA	NA	NA	NA	NA	NA
	Overweight	33	27.60	52.82	NA	NA	NA	NA	NA	NA
	Obese (≥ 30)	37	36.28	52.46	NA	NA	NA	NA	NA	NA
P value				.41						
Shohab et al.	Normal (< 24)	47	NA	43.29 ± 1.69	NA	NA	2.546 ± 0.89	NA	NA	NA
	Overweight (24-30)	56	NA	47.08 ± 1.29	NA	NA	2.801 ± 0.84	NA	NA	NA
	Obese (≥ 30)	26	NA	43.61±1.25	NA	NA	2.684 ± 0.74	NA	NA	NA
P value										
Simsek et al.	Normal (< 25)	849	NA	38.19 ± 14.1	490	215	NA	375	474	NA
	Overweight	883	NA	46.39 ± 12.9	510	205	NA	392	491	NA
	Obese (30-39)	334	NA	49.52 ± 12.8	217	83	NA	121	213	NA
	Morbid obese	36	NA	50.22 ± 11.1	20	10	NA	15	21	NA
P value				.001	.102	.896			.059	
Tomaszewski et al.	Normal (< 25)	61	NA	52.6	NA	NA	3.6	NA	NA	NA
	Overweight	45	NA	57.4	NA	NA	3.1	NA	NA	NA
	Obese (30-34.9)	43	NA	53	NA	NA	3.7	NA	NA	NA
	Morbid obese	38	NA	53	NA	NA	3.9	NA	NA	NA
P value				.34			.70			

*ANOVA, **Logistics Regression Analysis

Table 2. Operative characteristics in different studies.

Studies	Body Mass Index	Patients	Operation time	Complications, %	Multiple Accesses
Alyami et al.	Normal (< 25)	39	44.6	7	NA
	Overweight	24	43.4	8	NA
	Obese (30-39)	41	47	2	NA
	Morbid Obese	10	55	0	NA
P value			.3	.55	
Bagrodia et al.	Normal (< 25)	26	NA	26	4
	Overweight	44	NA	11	7
	Obese(30-39)	51	NA	19	5
	Morbid obese	29	NA	17	5
P value				.42	.76
Fuller et al.	Normal (< 25)	1394	NA	5	112
	Overweight	1568	NA	7	112
	Obese (30-39)	650	NA	5	44
	Super (≥ 40)	97	NA	4%	6
p value				2/0, /5.8*	< .001
El-Assym et al.	Normal (<25)	270	69.8 ± 32.4	NA	NA
	Overweight	235	71.4 ± 28.7	NA	NA
	Obese (30-39)	468	68.5 ± 29.6	NA	NA
	Morbid obese	92	77.2 ± 32.4	NA	NA
P value			.45		
Keheila et al.	Super (≥ **50**)	17	106	Na	7
p value					
Koo et al	Normal (< 25)	65	75.2	7	NA
	Overweight	79	68.8	8	NA
	Obese (30-39)	67	68.5	14	NA
	Morbid obese	12	81.4	16	NA
P value			.35		
Kuntz et al.	Normal (< 25)	55	NA	NA	5
	overweight	74	NA	NA	6
	Obese (30-35)	67	NA	NA	3
	Morbid Obese	72	NA	NA	3
P value					.664
Ortiz et al.	Normal (< 25)	77	101.7 ± 48.1	0	NA
	Overweight	93	96.6 ± 41.1	3%	NA
	Obese (30-39)	75	110.2±46.2	4%	NA
	Morbid obese	10	116.0 ± 49.8	0%	NA
P value			.2	.34**	
Sergeyev et al.	Normal (< 25)	15	NA	NA	NA
	Overweight	33	NA	NA	NA
	Obese (≥ 30)	37	NA	NA	NA
P value					
Shohab et al.	Normal (< 24)	47	128.4 ± 48.61	NA	NA
	Overweight (24-30)	56	126.62 ± 59.75	NA	NA
	Obese	26	129.42 ± 48.61	NA	NA
P value					
Simsek et al.	Normal (< 25)	849	66.44 ± 26.93	3	184
	Overweight	883	65.74 ± 28.69	4	147
	Obese (30-39)	334	66.13 ± 28.42	5	56
	Morbid obese	36	68.20 ± 24.66	5	7
P value			.638		.313
Tomaszewski et al.	Normal (< 25)	61	NA	NA	NA
	Overweight	45	NA	NA	NA
	Obese (30-34.9)	43	NA	NA	NA
	Morbid obese	38	NA	NA	NA
P value					

* Failed access/perforation/hydrothorax, respectively.

** Failure to get access.

Table 3. Postoperative Characteristics in different studies.

Studies	Body Mass Index	Patients	Stone Free Rate, %	Complications	Hospital Stay	Second Procedure	Hb Drop
Alyami et al.[29]	Normal (< 25)	39	90.0	5	1.6 (0.3)	0	1
	Overweight	24	87.0	2	1.9 (0.3)	1	1.8
	Obese (30-39)	41	90.0	9	1.5 (0.2)	3	1.2
	Morbid obese	10	80.0	20	1.7 (0.3)	1	1.5
P value			.8	.1	.59	.3	.13
Bagrodia et al.[21]	Normal (< 25)	26	46.0	NA	3	11	NA
	Overweight	44	50.0	NA	2	19	NA
	Obese (30-39)	51	53.0	NA	3	18	NA
	Morbid obese	29	41.0	NA	2	11	NA
P value					.21	.86	
Fuller et al.[22]	Normal (< 25)	1394	77.5	1	NA	12	NA
	Overweight	1568	79.7	2	NA	9	NA
	Obese (30-39)	650	78.9	18	NA	98	NA
	Super (≥ 40)	97	65.6	21	NA	27	NA
P value			.009	.707		< .001	
El-Assym et al.[30]	Normal (< 25)	270	83.70	6	3.4 ± 2.6	70	1.3 ± 1.4
	Overweight	235	86.70	9	3.3 ± 3	75	1.1 ± 1.3
	Obese (30-39)	468	84.80	5	3.3 ± 2.5	114	1.3 ± 1.4
	Morbid obese	92	84.70	7	3.1 ± 2	16	1.1 ± 1.4
P value			.38	.66	.38	.6	.13
Keheila et al.[15]	Super (≥ 50)	17	76.0	23	4.5	4	1.2
P value							
Koo et al.[23]	Normal (< 25)	65	79.0	10	5.4	NA	1.1
	Overweight	79	76.0	13	6.5	NA	1.4
	Obese (30-39)	67	79.0	8	6.1	NA	1.1
	Morbid obese	12	83.0	8	5.1	NA	1.5
P value			.93		.91		.17
Kuntz et al.[14]	Normal (< 25)	55	45.0	18	NA	NA	NA
	Overweight	74	36.0	21	NA	NA	NA
	Obese (30-39)	67	49.0	19	NA	NA	NA
	Morbid obese	72	41.0	16	NA	NA	NA
P value			.864	.89			
Ortiz et al.[28]	Normal (< 25)	77	76.60	31	5.2 ± 3.4	9	1.9 ± 1.9
	Overweight	93	68.80	35	5.7 ± 4.1	16	2.2 ± 2.0
	Obese (30-39)	75	78.70	29	5.2 ± 4.6	15	1.4 ± 1.4
	Morbid obese	10	90.0	10	5.3 ± 3.1	2	1.0 ± 1.4
P value			.29	.39	.84	.59	.02
Sergeyev et al.[16]	Normal (< 25)	15	93.0	NA	5.40	1	2.31
	Overweight	33	100.0	NA	3.64	0	2.25
	Obese (≥ 30)	37	89.0	NA	3.70	4	2.29
P value					.01		.98
Shohab et al.	Normal (< 24)	47	91.18	6	3.00 ± 1.04	NA	NA
	Overweight (24-30)	56	89.62	8	3.00 ± 1.17	NA	NA
	Obese	26	90.23	23	3.03 ± 1.82	NA	NA
P value							
Simsek et al.	Normal (< 25)	849	83.0	1	2.86 ± 1.56	NA	NA
	Overweight	883	80.9	1	2.90 ± 1.93	NA	NA
	Obese (30-39)	334	80.2	1	1.70 ± 1.58	NA	NA
	Morbid Obese	36	86.1	2	2.81 ± 0.98	NA	NA
P value							
Tomaszewski et al.	Normal (< 25)	61	80.6	NA	3.4	NA	6.2 (Htc)
	Overweight	45	76.9	NA	2.4	NA	7.3 (Htc)
	Obese (30-34.9)	43	77.0	NA	3	NA	6.5 (Htc)
	Morbid obese	38	78.9	NA	2.6	NA	5.3 (Htc)
P value			.82		.53		.22

Abbreviations: Hb, hemoglobin; Htc, hematocrit; NA, not applicable.

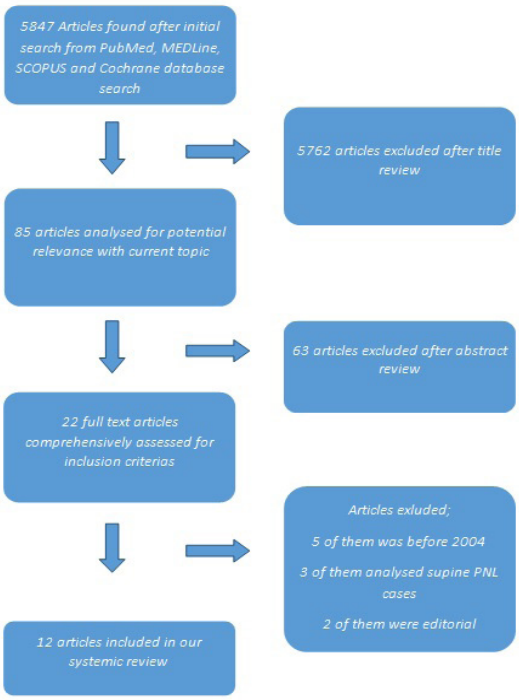

Figure. PRISMA Chart.

the definitions reported in the PRISMA Statement for reviewers (**Figure**). Two collaborators (FO and BU) independently reviewed all of the articles and data disagreement was resolved by a third reviewer or by consensus. Original research articles published in English language with accessibility to the full text article were analyzed for our review. Studies evaluating only the adult population were enrolled to our review. Additionally, we excluded expert opinions, editorials comments, studies evaluating the effect of supine PNL on obese patients, letters to the editor and case reports from our review. Additional citations were identified cautiously by reviewing reference lists of pertinent articles.

At the end of the evaluation, we found 12 articles in English language, analyzing the effect of obesity on prone PNL outcomes. Parameters like; total number of patients, BMI, age, male: female ratio, maximum stone diameter or stone burden, American Society of Anesthesiologists (ASA) score and history of previous renal stone surgery were taken into account. Perioperative parameters including operation time, fluoroscopy screening time, requirement of multiple access and perioperative complications were evaluated. Also, length of hospital stay, stone free rates, requirement of additional procedures and complications were collected.

RESULTS

All studies were evaluated in this review had a retrospective nature without randomization except Clinical Research Office of Endourology Society (CROES) study which had a prospective data collecting design. Additionally, reviewed original articles had different study designs which made it difficult to obtain a certain conclusion about the effect of obesity on PNL outcomes. Nine of the twelve articles were divided patients into four groups; normal weight, overweight, obese and morbid obese. Kuntz and colleagues and Tomaszewski and colleagues accepted obesity range BMI between 30 and 35 kg/m^2.[14,15] However, remaining seven articles defined obesity as BMI in the range of 30-39 kg/m^2. One study was interested with only results of PNL in super obese patients and super obese was defined as BMI > 50 kg/m^2.[16] Another two studies categorized patients who underwent PNL into three groups (normal weight, overweight, obese) and did not analyze morbid obese patients.[17,18]

Additionally, the mean BMI of each groups were calculated in only five of these studies and as expected, the mean BMI was significantly higher in morbid obese patients. The ASA score of the patients was mentioned in five comparative studies and in two articles the ASA score was significantly higher in obese and morbid obese patients. The mean operation times and means fluoroscopy screening times were given in six and in one comparative studies, respectively, without any statically significant difference (**Tables 1 and 2**).

Stone free status of patients was in wide range between 49%-90% in obese patients and 41%-90% in morbid obese patients. However, when each study evaluated in their own study groups, there was no statistically significant difference in stone free rates. Similarly, post-operative complications were not significantly different in morbid obese and obese patients when compared with normal weight and over weight patients. The results of the included studies from the literature for our review are summarized in **Table 3**.

DISCUSSION

With increasing BMI, metabolic disorders such as hypercalciuria, hyperoxaluria, hyperinsulinemia and low urine volume are more commonly seen and these conditions are also strong risk factors for stone formation.[19] Because of all these, obese and morbid obese patients are more likely to face with renal stone disease. Although, extracorporeal shock wave lithotripsy (SWL) is accepted as one of the first line treatment modalities for kidney stones < 20 mm, according to the guidelines,

longer skin to stone distance (SSD) and difficulties in focusing the stone under ultrasonography or fluoroscopy guidance reduces SWL success rates in obese patients.[20] On the other hand, several studies mentioned that effectiveness of Flexible ureterorenoscopy (f-URS) was decreased and requirement of second intervention is increased with the increase in stone size.[21,22] Multiple interventions may lead to more anesthetic usage and surgical complications in obese patients. Recently, PNL still remains one of the most important treatment options for renal stone treatment.

In obese patients, anesthetic and pre-surgical problems can be challenging for urologists. Five studies evaluated the ASA score of patients who underwent PNL and two of them had demonstrated patients with > 3 ASA score were more common in obese and morbid obese patients.[14,23-26] Also, complications including atelectasis, venous thromboembolism and longer recovery period may be associated with higher ASA scores.[27] Conversely, other two studies failed to show significant difference between groups according to their BMI's. Additionally, changing patients from lithotomy position to prone position requires special attention and more trained personnel, especially in obese patients. Being a center with high stone patients volume, may have resulted in increased experience of surgeons, anesthetists and personnel that prevent unfortunate pre-operative events.

Complete clearance of the stone after PNL operation is the most pleasing condition for urologist and also for the patient. Stone free status after PNL in obese patients was surprisingly in a wide range (49%-90% in obese patients and 41%-90% in morbid obese patients) according to the studies in the literature. These differences may due to different defining criteria for the term 'success' among different articles. Stone free status accepted as complete clearance of stone and presence of residual fragments by some authors. Other studies neglect the presence of residual stone fragments < 5 mm and define these conditions as stone free. Moreover, some authors evaluated stone free status by abdominal computerized tomography and others used intravenous urography (IVU) or ultrasonography.[14,23] It is clear that imaging modalities have different sensitivities in detecting stone(s) and this difference may lead to misinterpretation of the results.[28,29] However, when each study is evaluated on its own, no difference was detected in groups with different BMI's.

The mean operation time was given in four comparative studies and all of them demonstrated significantly longer operation time in morbid obese patients. However, the differences were not statically significant. Moreover, none of these studies had given an exact definition of operative time. To our knowledge, some authors accepted operation time from beginning of anesthesia to nephrostomy tube placement but others accepted operative time from access attempt to nephrostomy tube placement.[30] This difference in calculations can lead to confusion when assessing the effect of BMI on PNL operation time. We believe that, calculating the operation time from anesthesia induction to the end of the operation is a more reliable approach to identify the effect of high BMI on PNL operation time.

Deterioration of image quality of stone and target calyx due to extensive fat tissue in obese patients was mentioned above. In the light of this information, fluoroscopy screening time is expected to be influenced by BMI. However, only Ortiz and colleagues. discussed fluoroscopy screening time and found that the fluoroscopy screening time became longer with increasing BMI but their findings were not statistically significant.[31] Radiation exposure to the surgical team and patients is an important issue. Because of high recurrence risk of nephrolithiasis and technical difficulties of PNL in obese patients, longer fluoroscopy screening times are expected and this issue must be assessed carefully in further studies.

The mean hospitalization time was similar in six comparative studies. Only Sergeyev and colleagues had demonstrated a significant difference in between groups according to their BMI's.[17] Surprisingly, patients with normal weight had longer hospitalization times when compared with overweight and obese patients. We believe that longer hospitalization time is associated with operative or post operative complications such as bleeding, fever, adjacent organ injuries instead of technical difficulties. Sergeyev and colleagues and and colleagues did not mention about their complications after PNL in details. The hospitalization time was longer in Koo and colleagues and Ortiz and colleagues studies and as expected, their complication rates were higher when compared with other studies.[25,31]

Requirement of additional procedures was discussed in five studies. Alyami and colleagues reported 8% and 10% re-admission rates in obese and morbid obese patients, respectively, but they did not mention about the additional procedures in detail.[32] Sergeyev and colleagues only mentioned about second-look PNL after initial procedure and they performed it only in five of their patients (1/15 in normal weight patients and 4/37 in morbid obese patients).[17] In Bagrodia's study, need for a second look PNL rates were 35% and 38% in

obese and morbid obese patients, respectively, much higher when compared with Sergeyev and colleagues study.[23] However, there was no statistically significant difference in between groups. Similarly, requirement of second procedures including PNL, URS and SWL, were similar between groups in both El-Assmy and colleagues and Ortiz and colleagues studies.[31,33]

Bleeding is one of the most serious complications of PNL procedure, 2%-45% and 0.8% of patients required blood transfusion and angioembolization, respectively.[34] All studies analyzed the hemoglobin drop after PNL procedure and there was no association between bleeding rates and BMI values of the patients. Obesity seems to be a technical challenge for urologists while performing access into the calyceal system. We believe that bleeding complication rates are associated with the experience of the surgeon, applying multiple accesses into the system and history of previous surgeries, instead of technical difficulties during PNL surgery.

It is quite complicated to assess the effect of obesity and morbid obesity on prone PNL complications due to different classification systems in different studies. Ortiz and colleagues used Clavien complication classification to categorize complications.[31] However, Koo and colleagues classified their complications as minor and major complications.[25] Differently, El-Assmy did not categories the complications under subgroups, instead, they listed all the complications separately.[33] Due to this different classification system, it is quite difficult to assess all the studies and come up with a certain result. However, when we assess all the studies separately, complication rates were not statistically significant between different BMI groups.

CONCLUSIONS

PNL is a safe and effective treatment modality for renal stone(s) in obese and morbid obese patients. However, effect of body mass index on PNL outcomes including operation time, fluoroscopy screening time, hospitalization time, complications and stone free status are still debatable. Role of obesity on PNL outcomes must be investigated by further prospective, randomized studies with larger patient volumes.

CONFLICT OF INTEREST

None declared.

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