Preoperative nutritional factors and outcomes after radical cystectomy: A narrative review

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Abstract

Only a few nutritional factors have been identified to predict the risk of developing complications after radical cystectomy (RC). This narrative review delineates the current known effects of preoperative nutritional status factors in this context. The report highlighted the heterogeneity between study methods and results. We determined that low albuminemia values increase mortality risk and overall complications. In addition, obesity tends to increase the risk of developing venous thromboembolism and adverse events. Additional prospective studies, using standardized methods to both define and report complications, should be conducted to strengthen the connections between preoperative nutritional status factors and post-RC complications. Furthermore, intervention studies testing the impact of strategies to improve nutritional status on the risk of complications after RC are also needed.

Introduction

Bladder cancer (BCa) is the fifth most commonly diagnosed neoplasm in the USA[1] and is one of the cancers with the highest financial burden from diagnosis to death, essentially due to the large number of procedures required for its management [2]. Radical cystectomy (RC) with urinary diversion is the standard surgical treatment for muscle invasive BCa. The rate of short- and long-term complications after RC remains high despite major improvements in surgical techniques and perioperative subject care [3,4]. While many studies have evaluated improved surgical techniques, no modifiable preoperative nutritional risk factors for post-RC complications have emerged to improve BCa outcomes [4]. Nutritional status is a confounding factor in a cancer patient's response to surgical stress [5]. The prevalence of malnutrition (nutrition risk score >3)[6] in subjects admitted to the hospital for urological surgery ranges from 20-50% [7,8]. Since nutritional status is a modifiable preoperative factor, subjects could benefit from preoperative nutritional intervention to decrease complications related to cancer surgery [7,9]. Being able to link the risk factor for RC complications with preoperative nutritional status is therefore important in order to better stratify RC-eligible patients.

A growing body of literature has identified preoperative factors associated with complications after RC. We conducted a comprehensive review to determine the current effects of preoperative nutritional status factors on complications after RC.

Methods

Investigators with experience conducting systematic reviews and experts in epidemiology, nutrition and urological oncology with a particular clinical interest in radical cystectomy designed the protocol and worked on this comprehensive review.

Research methods

We designed a strategy to identify the association between traditional factors of nutritional status and the risk of complications after RC. We carried out an electronic search of the MEDLINE and EBSCO databases using keywords "cystectomy" and/or "mortality" and/or "complications" and/or "nutritional status" and/or "nutrition" and/or "nutritional" and/or "body mass index (BMI)" and/or "BMI" and /or "albumin" and/or "weight loss." We retained all English language cohort and case-control studies that evaluate at least one preoperative nutritional status factor and the risk of complications or mortality after RC. We included studies published between January 1, 2005, and December 31, 2016, since the quality criteria for reporting surgical complications was introduced in 2002 [10].

A registered dietitian (JA) conducted the first research and analysis of the articles. A urology resident (TBZ) independently validated the review and also analysed the articles and quality assessment. Disagreements were resolved by consultation with a third reviewer (VF) to reach a consensus.

Results

We included 40 studies in the review (Table1). Nine studies used at least one of the following standardized methods for reporting complications: Clavien-Dindo [11], Common Terminology Criteria for Adverse Events 3.0 [12], Memorial Sloan Kettering Cancer Center (MSKCC) [3] classifications. The remaining 31 studies used length of hospital stay, occurrence of any adverse event, specific complication (ileus, delirium, symptomatic venous thromboembolism, parastomal hernia, wound dehiscence) and/or mortality as study outcomes. We found no published randomized trial of nutritional assessment or intervention prior to radical cystectomy.

1. Standardized method of reporting outcomes

1.1 Body mass index

Among the nine studies with standardized methods of reporting complications, eight looked at the effect of BMI [3,13-19]. In the Berger *et al.* study [15], high BMI was associated with a higher risk of developing complications after RC but not with the mortality rate. Roghmann *et al.* [17] observed that BMI was associated with a higher risk of developing overall complications and high-grade complications. In a multicentre study, Osawa *et al.* [19] reviewed data from 813 patients in Japanese institutions and 1,427 patients in US institutions who underwent RC between January 1997 and April 2014. High BMI was associated with a higher 90-day (d) risk of mortality and morbidity. Other studies did not find any association between BMI and RC outcomes.

1.2 Albuminemia

Garg *et al.* also found that low albuminemia concentration was associated with a higher 90d risk of complications and mortality after RC [18,20]. In a prospective design, Mursi *et al.* [16] found no difference in complication rate and grade, re-admission rate and length of hospital stay between the low and normal albuminemia groups.

2. Using the National Surgical Quality Improvement Program (NSQIP) database

2.1 Body mass index

Five studies examined the association between BMI and RC outcomes using the NSQIP database [21-25]. In the Gandaglia *et al.* study [21], a BMI $>30 kg/m^2$ was associated with a higher risk of developing overall complications within 30d after RC, compared to a BMI $<25 kg/m^2$. Meyer *et al.* [25] found that subjects with a BMI between 25-30 and $>30 kg/m^2$ were at higher risk of developing wound dehiscence compared to patients with a BMI $<25 kg/m^2$. BMI was not associated with RC outcomes in other studies.

2.2 Albuminemia

The association between albuminemia and RC outcomes was assessed in six studies using the NSQIP database [21-23,25-27]. All authors except Meyer *et al.* [25] found an association between low albuminemia (<3.5g/dl) and a higher risk of complications after RC (early complications, morbidity and prolonged hospital stay) compared with subjects with albuminemia ≥3.5 or >4.1 g/dl. Albuminemia was not associated with wound dehiscence after RC in Meyer *et al*. [25].

2.3 Weight loss

Hollenbeck *et al.* [26] observed increased mortality within 90d after RC in subjects who sustained a weight loss >10% within six months before RC compared to those who sustained no weight loss or a weight loss <10%. Preoperative weight loss of more than 10% was not associated with a prolonged length of hospital stay in this study. In Johnson *et al.* [22] and Lavallée *et al.* [23], BMI and weight loss ≥10% were not identified as a predictor of complications within 30d after RC.

3. Non-standardized method of reporting outcomes

3.1 Multicentre studies

3.1.1 Nutritional Score

Jensen *et al.* [28] investigated the association between nutritional risk and length of hospital stay among 246 RC subjects at the MSKCC in New York and the Aarhus University Hospital in Denmark in 2009. Nutritional risk before RC has been assessed by the Subjective Global Assessment Scale [29] at MSKCC and by the Nutrition Risk Screening (NRS) [6] in Denmark. Nutritional risk was not associated with a higher length of stay after RC in this study.

3.1.2 Body mass index

Four multicentre studies looked at the association between BMI and RC outcomes [28,30-32]. BMI $\geq$30kg/m^2 (vs.<25kg/m^2) was an independent predictor of overall and cancer-specific mortality [30]. Higher BMI was associated with cancer-specific mortality in patients with soft tissue surgical margin involvement at RC, but the association was not found to be significant using multivariate analysis [31]. BMI was not associated with RC outcomes in the other two studies.

4. Other study designs

4.1 Body mass index

Twelve studies investigated the association between BMI and RC outcomes [33-44]. Reyes *et al.* [33] found that tract infections, pyelonephritis, wound infections and overall complications were less frequent in normal-weight patients (18.5-24.9kg/m^2) compared to overweight (25-29.9kg/m^2) and obese ($\geq$30.0kg/m^2) patients. BMI was not a predictor of mortality and complication development after RC in the Maurer *et al.* [35] study, except for postoperative bleeding, which was more frequent in subjects with a high BMI. Compared to subjects with a BMI of 18-25kg/m^2, subjects with a BMI >30kg/m^2 had a higher risk of cancer-specific mortality [38,42], incisional hernia [40], re-admission 30d and 90d after RC [39], ileus [36], parastomal hernia [45] and deep venous thrombosis [43,44].

Psutka *et al.* [41] investigated the impact of BMI and fat mass index on mortality after RC at the Mayo Clinic in Minnesota in 515 RC subjects from 2000-2008. Higher BMI was associated with improved overall survival, while fat mass index was not.

Butt *et al.* [34] found no association between BMI and complication rates in 51 consecutive subjects of robot-assisted RC. With a participation rate of 45%, Large *et al.* [37] found no difference between the BMI of subjects who did or did not develop delirium after RC in 91 subjects.

4.2 Nutritional score

Gregg *et al.* [46] defined nutritional deficiency before RC as the presence of one or more of the following factors: albuminemia <3.5g/dl, BMI <18.5kg/m^2 or preoperative weight loss <5%. In comparison with subjects who had a normal nutritional status, defined as the absence of the same three factors, nutritional deficiency was a predictor of mortality within 90d after RC.

4.3 Albuminemia

Low albuminemia was associated with a higher risk of parastomal hernia [45], mortality within 90d after RC [47-50], a longer hospital stay or re-admission before 90d after RC [48] and a higher prevalence of complications after RC [48].

Liu *et al.* [51] reported that a low serum albumin/(total protein–albumin) ratio has been correlated with tumour progression. A ratio ≥1.6 was associated with a lower risk of cancer-specific mortality after RC in this cohort.

Discussion

The reporting of post-operative complications has improved [10] in the era of modern surgical techniques and perioperative support (2005). For this reason, we conducted a review of publications involving nutritional evaluation and RC complications. In the 40 publications, albuminemia and BMI were the two major nutritional factors reported (**Table2**). Even though albuminemia is no longer considered as a marker of nutritional status, it has been shown to be associated with poor outcomes after RC. It has been suggested that low preoperative albuminemia increases the risk of mortality and complications after RC. Obesity (BMI >30kg/m^2), also seemed to increase the risk of developing venous thromboembolism and adverse events after RC. Disparities between statistical methods, the accuracy of reporting and the definition of preoperative factors and/or surgical outcomes are important limitations for cross study comparisons. Due to the wide heterogeneity of study designs and methods used in assessing nutritional status and complications, it is difficult to identify other nutritional factors associated with RC complications.

More than ten years after the landmark paper published by Martin *et al.* [10], disparities in the reporting of post-operative urological oncology complications still occur in the literature [52]. Partly based on recommendations in the Martin *et al.* [10] study, a 2007 report by Dr. Donat strongly recommended the use of both standardized severity grading scale and a category classification method for reporting complications after RC [52]. In the present review, 31 studies did not use a standardized complication-reporting tool, indicating significant ongoing disparities in the literature today.

Studies were mainly conducted using institutional and national databases and were not designed to investigate the impact of nutritional status on RC outcomes. Retrospective studies have the advantage of less costly access to a larger potential sample size compared to prospective studies, but with an increased risk of selection bias. More than 80% accrued nutritional data retrospectively, similar to the 87% reported in 2007 [52]. Psutka *et al.* [41] conducted sensibility analysis to test for possible bias introduced by the exclusion of patients with missing data, but this was unfortunately not discussed in the majority of the literature reported here.

Many studies also observed the impact of BMI on complications and mortality after RC using regression models. Since U-shaped associations are common for BMI and surgery outcomes and mortality [53], the log-linear relationship between the independent variable (BMI) and the dependent variable (complication) should be confirmed before regression modelling. It is often not stated whether this was verified [14,15,17-19,22,28,31,35,36,39,41,44,45]. Other researchers modelled BMI as categorized variables

(>30vs.≤30kg/m^2 [3,24,30,40,43], ≥35vs.<25kg/m^2 [23], ≥22vs.<22kg/m^2 [42] or in more than two groups [21,25,33,38]).

Despite the validity of NRS for assessing nutritional status in clinical practice [54], NRS [6] was used in only two studies, with a sample size of 76 subjects each. Further studies are needed to determine whether the NRS can stratify the risk of complications after RC. Most of the studies assessed nutritional status by one single factor, such as BMI or albuminemia. Despite increasing evidence that serum proteins like albumin are not specific indicators of nutritional status [55], it is still used as a single factor to assess it and to measure the impact of nutritional interventions. Serum protein concentration does not depend on nutritional status alone, but on many other additional factors [55], such as inflammation or hydration. More comprehensive nutritional scores that involve multiple criteria will likely better define nutritional status and risk-stratify subjects more accurately.

Complications after RC are frequent, with over 67% of subjects developing one or several complications [3]. Some papers used a statistical test instead of (or in addition to) a regression model [13,15,16,20,24,25,32-37,49], which does not consider the effect of potential confounders. Regression models that consider a time-dependant complication count, specific to each patient, as well as the types of complication, would be more accurate in assessing outcomes after RC.

The weaknesses of the studies stem mainly from the retrospective study design, lack of control for potential confounders and non-standardized data collection methods for nutritional status and complications after RC. Thus, to move this field forward, it is important to conduct more prospective studies that use standardized methods to define nutritional status before RC and report well-defined well-classified complications after RC. For example, the measurement of sarcopenia using CT scan or the assessment of frailty using grip strength are now used to define nutritional status in elderly subjects [56]. The European Society for Clinical Nutrition and Metabolism recently published the validation of their diagnostic criteria for malnutrition tool in hospitalized patients.[57] To the best of our knowledge, no published randomized controlled trial has observed the impact of pre-operative optimization of nutritional status on post-RC outcomes. Few studies observed a positive impact of the introduction of an enhanced recovery after surgery (ERAS) protocol on RC outcomes. However, ERAS protocols typically only optimize short term nutritional factors before surgery using an immediate pre-operative carbohydrate loading. [58,59] Those protocols are designed to accelerate post-operative recovery, not improve the overall nutritional status of a patient.

Conclusion

A significant effort has been made in the last ten years for RC surgical amelioration. The high risk of selection bias in retrospective studies, heterogeneity among methods and the use of a single factor to assess nutritional status make it difficult to predict complications after RC. Low albuminemia tends to increase the risk of mortality and overall complications, while obesity (BMI >30kg/m^2) appears to increase the risk of developing venous thromboembolism and adverse events after RC. No other factor has been associated with the risk of mortality and complications after RC. Prospective studies with a larger sample size are needed to determine the capacity of standardized tools to assess nutritional status and identify subjects at high risk of complications after RC. In addition, further studies are required and justified to determine the impact of preoperative nutritional status improvement on risk of complications and other outcomes after RC.

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Figures and Tables

Table 1. Summary of the studies included in this narrative review

First author	Year	Eligible subjects (n)	Factor(s) of nutritional evaluation	Outcome	Results	Methods of classification for complications
Hollenbeck[26]	2006	2,538	Albuminemia and ≥10% weight loss	Length of hospital stay (>30d) and mortality	Logistic regression: Length of stay ≥30d: albuminemia ≤3.5g/dl (OR 2.1, 95% CI 1.2 to 3.8). Mortality within 30d: weight loss ≥10% (OR 2.7, 95% CI 1.1 to 6.4), 90d: albuminemia ≤3.5g/dl, (OR 12.0, 95% CI 2.8 to 51.0), weight loss ≥10% (OR 2.9, 95% CI 1.5 to 5.4).	
Reyes[33]	2006	343	BMI	Neobladder-related outcomes, pyelonephritis, incisional hernia, wound infections, wound dehiscence and voiding patterns.	Chi-Square test: Normal weight vs. overweight vs. obese subjects: Overall complications (p=0.012), urinary tract infection (p=0.001), pyelonephritis (p=0.04), wound infection (p=0.04) were less frequent in the normal weight group.	
Butt[34]	2008	51	BMI	Complications rate, hospital length of stay, mortality	Kruskal-Wallis and Fisher's exact test: Hospital length of stay (results not provided), complications rate (NS), mortality (only one event).	
Maurer[35]	2010	390	BMI	Complications and mortality within 90d after RC	Mann-Whitney test: Higher BMI: 30d postoperative bleeding rate (p=0.02), other complications (NS), mortality (NS). Cox regression: Mortality (NS).	
Novara[13]	2009	358	BMI	All complications and high-grade complications (including mortality) within 90d after RC	NS.	MSKCC and Clavien-Dindo

Shabsigh[3]	2009	1320	BMI	All complications and high-grade complications within 90d after RC	NS.	MSKCC and Clavien-Dindo
Svatek[14]	2009	283	BMI	Any AE within 90d after RC	Logistic regression: AE 90d: BMI (OR 1.16, 95% CI 1.08 to 1.23). High-grade (2-4): BMI (OR 1.10, 95% CI 1.04 to 1.16).	Common Terminology Criteria Adverse Events
Svatek[36]	2010	283	BMI	Ileus	Fisher's exact test: (p=0.014). Logistic regression: (OR 1.09, 95% CI 1.03 to 1.17)	
Gregg[46]	2011	905	Nutritional risk was defined as one or more factor between: albuminemia <3.5 g/dl, BMI<18.5 and >5% weight loss	Overall mortality, mortality within and after 90d after RC	Cox regression: Overall survival (HR 1.82, 95% CI 1.25 to 2.65), within 90d (HR 2.91, 95% CI 1.36 to 6.23), after 90d (HR 1.55, 95% CI 1.01 to 2.38).	
Morgan[47]	2011	220	Albuminemia	Mortality 90d after RC in ≥75 years old subjects	Cox regression: Albuminemia <3.7g/dl (HR 2.50, 95% CI 1.40 to 4.45)	
Lambert[49]	2012	238	Albuminemia	Complications and overall and cancer-specific mortality after RC	2-sample test: Overall complications: Albuminemia <3.5g/dl vs. normal albuminemia (p=0.014). Cox regression: Overall survival: Albuminemia <3.5g/dl (HR 1.76, p=0.04), cancer-specific survival: NS.	
Large[37]	2012	91	BMI	Delirium	NS.	
Berger[15]	2013	256	BMI	Inpatient complication and mortality within 90d	Logistic regression: Inpatient complications (continuously, OR 1.13, 95% CI 1.02 to 1.24), mortality (NS). Log-rank test: mortality (NS).	Clavien-Dindo
Chan[50]	2013	117	Albuminemia	Overall mortality rate at 5-years after RC	Cox regression: Albuminemia >3.9g/dl (HR 0.946, 95% CI 0.902 to 0.992, p=0.022).	

Chromecki[30]	2013	4,118	BMI	Cancer-specific and overall mortality	Cox regression: BMI >30 kg/m^2: Cancer specific mortality (HR 1.43, 95% CI 1.24 to 1.66, p<0.001), overall mortality (HR 1.81, 95% CI 1.60 to 2.05, p<0.001). Similar results for BMI as a continuous variable (all p values <0.001).	
Djaladat[48]	2013	1,964	Albuminemia	Any adverse event leading to lengthening hospital stay or re-admission occurring within 90d after RC, mortality within 90d recurrence-free survival and overall survival at 5 years	Logistic regression: Complications within 90d (NS), mortality within 90d (few events n=15). Cox regression: Recurrence free survival (HR 1.68, 95% CI 1.16 to 2.43), overall survival (HR 1.93, 95% CI 1.43 to 2.63).	
Jensen[54]	2013	82	NRS	Length of hospital stay (≥11d)	NS.	
Mursi[16]	2013	31	Albuminemia, BMI	Early (≤30d), late (31 to 90d) and cumulative (<90d) readmission rate, complications rate and grade and mortality after RC	Chi-Square: albuminemia <3.5g/dl: higher mortality rate (p=0.048, but few events), NS for other outcomes. BMI: NS.	Clavien-Dindo
Xylinas[31]	2013	231	BMI	Cancer specific mortality	Cox regression: Modeled continuously (HR 1.50, 95% CI 0.99 to 2.24, p=0.052)	
Al-Daghmin[39]	2014	272	BMI	30 and 90d readmission rate	Logistic regression: 30 days (OR 1.12, 95% CI 1.05 to 1.19, p=0.004). 90 days (OR 1.10, 95% CI 1.0 to 1.17, p=0.004).	
Bachir[32]	2014	847	BMI	Overall survival and disease specific survival	Kaplan-Meier: No differences in overall survival (p=0.32) and disease specific survival (p=0.35) between among BMI subgroups (<25, 25 to 29 and >=30 kg/m^2).	

Donahue[45]	2014	386	Albuminemia, BMI	Parastomal hernia within 2 years after RC	Cox regression: Albuminemia (continuously, HR 0.43, 95% CI 0.25 to 0.75, p<0.003). BMI (continuously, HR 1.08, 95% CI 1.05 to 1.12, p<0.0001).	
Garg[20]	2014	1,320	Albuminemia	Complications within 30 and 90d and mortality at 90d after RC	Fisher's exact test: Albuminemia <4 vs ≥4g/dl: Complications at 30d: neurological (p=0.001), wound (p<0.001), any complication (p=0.005). Complications between 60 and 90d (NS). Logistic regression: Grade 1 to 5 complications within 90d: (continuously, OR 0.61, 95% CI 0.42 to 0.90). Mortality within 90d: (continuously, OR 0.33, 95% CI 0.14 to 0.75).	MSKCC and Clavien-Dindo
Gandaglia[21]	2014	1,094	Albuminemia, BMI	Complications within 30d (overall complications, prolonged operative time, prolonged length of stay, perioperative mortality).	Logistic regression: Overall complication: Albuminemia: unknown vs. >=3g/dl (OR 0.64, 96% CI 0.48 to 0.85, p=0.01). BMI >30 vs. <25 kg/m2 (OR 1.67, 95% CI 1.16 to 2.42, p=0.01). Other outcomes: NS.	-
Johnson[22]	2014	1,213	Albuminemia, >10% weight loss within 6 month before RC and BMI	Complications within 30d after RC	Logistic regression: Albuminemia <3.5g/dl (OR 1.79, 95% CI 1.06 to 3.03). BMI: NS. Weight loss: NS.	
Lavallée[23]	2014	2,303	Albuminemia, >10% weight loss within 6 month before RC and BMI	Complications within 30d after RC	NS.	
Psutka[41]	2014	262	BMI and fat mass index	Overall survival	Cox regression: Increasing BMI correlated with improved overall survival (p=0.03), fat mass index (NS).	

Roghmann[17]	2014	535	BMI	All complications and high-grade complications within 90d after RC	Logistic regression: Any complication (OR 1.08, 95% CI 1.03 to 1.13). High-grade (3 and 4, OR 1.07, 95% CI 1.02 to 1.12).	MSKCC and Clavien-Dindo
Tyson[24]	2014	1,293	BMI	30d outcomes after RC: mortality, wound events, sepsis, pulmonary events, renal failure, thromboembolic and cardiac events, hospital length of stay, rates of return to operating suite, total operative time and total blood transfusions.	Fisher's exact test: BMI <30 vs. ≥30 kg/m^2: operative time (p=0.04), NS for other outcomes.	
Wan[18]	2014	247	Albuminemia, BMI, SMI	Complications within 90d	Logistic regression: Overall complication: Albuminemia <3.5g/dl (OR 3.63, 95% CI 1.20 to 11.00, p=0.0023), BMI (NS), SMI (NS). High-grade complications: Albuminemia (NS), BMI (NS), SMI (OR 0.95, 95%CI 0.92 to 0.99, p=0.017).	Clavien-Dindo
Hinata[42]	2015	730	Albuminemia, BMI	Overall survival	Cox regression: Albuminemia <3.5g/dl vs. 3.5 g/dl (NS). BMI <22kg/m^2 vs. ≥22 kg/m^2 (HR 1.65, 95% CI 1.17 to 2.33, p=0.004).	
Meyer[25]	2015	1,776	Albuminemia, BMI	Wound dehiscence	Logistic regression: BMI between 25 and 30 kg/m^2 (OR 2.1, 95% CI 1.1 to 3.9, p=0.02) and BMI >30 kg/m^2 (OR 2.3, 95% CI 1.3 to 4.4, p=0.008) vs. BMI <25kg/m^2. Chi-Square: Albuminemia (NS), BMI (p=0.015).	
Potretzke[43]	2015	241	BMI	Symptomatic venous thromboembolic events within 90d after RC	Logistic regression: BMI ≥30kg/m^2 vs. <30kg/m^2 (OR 4.69, 95% CI 1.70 to 12.92).	
Sun[44]	2015	2,316	BMI	Symptomatic venous thromboembolism within 90d after RC	Logistic regression: BMI (p=0.0015).	

Caras[27]	2016	1,374	Albuminemia	30d complications (morbidity and mortality)	Logistic regression: Albuminemia <3.5g/dl: Morbidity (OR 1.49, p=0.006), Mortality (NS).	
Dabi[38]	2016	701	BMI	Cancer-specific mortality	Cox regression: BMI >30 kg/m^2 vs. 18 to 25 kg/m^2 (HR 1.58, 95% CI 1.06 to 2.34, p=0.02).	
Jensen[28]	2016	246	BMI, nutritional status	Length of hospital stay	Linear regression: BMI continuously (NS), Nutritional status (NS).	
Liu[51]	2016	296	Albuminemia/ (total proteinemia/ albuminemia) ratio	Cancer-specific mortality	Cox regression: Ratio ≥1.6 (HR 0.28, 95% CI 0.12 to 0.68, p=0.005).	
Movassaghi[40]	2016	670	BMI	Parastomal and incisional hernia	Cox regression: BMI ≥30kg/m^2 vs. <30kg/m^2: Parastomal hernia (NS), Incisional hernia (HR 2.11, 95% CI 1.26 to 3.56, p=0.004).	
Osawa[19]	2016	2,240	BMI	90d complications (morbidity (Clavien-Dindo grade 3-5) and mortality)	Logistic regression: 90d mortality: continuously (OR 1.07, 95% CI 1.02 to 1.12, p=0.004), 90d morbidity continuously (OR 1.04, 95% CI 1.02 to 1.07, p<0.001).	Clavien-Dindo

AE: adverse event; BMI: body mass index; MSKCC: Memorial Sloan Kettering Cancer Classification; Nb: number; NRS: nutritional risk screening; NS: non-statistically significant; RC: radical cystectomy; SMI: skeletal muscle index.

Table 2. RC outcomes associated with serum albumin and BMI

Nutritional factor	**Outcome**
Serum albumin	
Low	- Mortality (late>early) (7 studies) - Overall complications (late and early) (6 studies) - Longer hospitalization (1 study) - Parastomal hernia (1 study)
BMI	
Low	- Mortality (1 study)
High	- Adverse events (5 studies) - Cancer-specific mortality (1 study) - Deep venous thrombosis (2 studies) - Ileus (1 study) - Improved survival (1 study) - Incisional hernia (1 study) - Mortality (3 studies) - Operative time (1 study) - Parastomal hernia (1 study) - Postoperative bleeding (1 study) - Readmission rate (1 study) - Urinary tract infection/pyelonephritis/wound infection (neobladder reconstruction) (1 study) - Wound dehiscence (1 study)

BMI: body mass index; RC: radical cystectomy.