Review

# The impact of BMI on surgical outcomes, a literature review

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## Abstract

The prevalence of being both underweight and overweight is increasing. It is critical that we understand how BMI contributes to human health and wellbeing. This literature review focusses on the impact BMI has on surgical outcomes and encompasses various procedures. The literature was reviewed from a variety of surgical journal publications over a period from 2008 to 2022.

Being underweight (BMI<18) carried increased risk of poor surgical outcomes, including mortality and morbidity. Numerous studies suggest that some degree of obesity (BMI>30) has a protective effect on mortality, giving rise to the 'obesity paradox', whilst others report the opposite effect. Despite this, the risk of significant morbidity increased as BMI increased.

Overall, BMI does have an impact on surgical outcomes, those who are underweight have an increased risk of mortality and morbidity. Those who are obese may carry lower risk of mortality, however, they have increased risk of significant morbidity.

## Abbreviations

*BMI – Body Mass Index*

## Introduction

Over the past 15 years the prevalence of those underweight (BMI<18), overweight (BMI>25 to BMI<30) and of obesity (BMI>30) has continued to increase.[1] This highlights the importance of research into how BMI can impact on human health and wellbeing. The literature suggests that obesity can have a large impact on human health and the development of negative health outcomes such as hypertension, cardiovascular disease and diabetes mellitus.[2] However, this literature review focusses specifically on the impact BMI has on surgical outcomes and includes a variety of acute emergency surgeries as well as planned, elective surgeries. As the population ages and life expectancy increases, the number of surgical procedures an average person receives is also increasing. It is estimated that the average person will undergo approximately six major surgical procedures in an 85-year life.[3] Therefore, it should be a priority to understand how different lifestyle factors, such as BMI, can impact surgical outcomes, so that we can better optimise patient care in the perioperative period.

## Methods

A PubMed search was conducted to find relevant literature by searching for the keywords 'BMI' or 'body weight', and 'surgical/perioperative/operative outcomes' in the title or abstract. The search was further refined by excluding any literature containing 'bariatric surgery' as this is not accessible to patients of all BMI groups and makes it difficult to ascertain the impact BMI has in these cases. Literature was selected that explored the relationship between BMI and surgical outcomes directly, specifically mortality and morbidity, but also other long-term health implications resulting directly from surgery. The main exclusion criterium was if the literature was outside the scope of the review, this included literature that had a primary focus on factors outside of BMI and surgical outcomes or did not explore the impact of BMI at all. Literature focussed on surgery undertaken by a single demographic was also excluded.

## Results

A total of 26,580 people across the USA, China, Japan and Germany were included and various procedures were chosen. These procedures include vascular surgery (aneurysm, cerebrovascular, amputation), intra-abdominal cancer surgery, otolaryngology-head and neck surgery, laparoscopic hepatectomy, oncological microvascular head and neck reconstruction, hepatic resection, total gastrectomy, and emergency laparotomy for high-risk abdominal emergencies.

Across the four studies that included an underweight (BMI<18) category there was a unanimous increase in 30-day mortality compared to a normal control group. This increase varied from 31% for vascular surgical interventions 2 to 500% in major intra-abdominal cancer operations after adjustment for confounding.[4] In addition to increased 30-day mortality in the postoperative period those in the underweight category were shown to be more likely to need unexpected further surgery ($P \leq 0.05$), further increasing the risk of complications and mortality.[2] A study into the outcomes of patients following hepatic resection identified a link between low BMI and risk of stroke. Those who were underweight were at 10 times greater risk of stroke following the operation compared to the control group ($P=0.014$).[8] In addition, the risk of morbidity in patients with low BMI was 25.4% greater following vascular surgery when compared to a control group. This arises from an increased risk of multiple complications, including a 70.8% increased risk of systemic infection, a 49.5% increased risk of respiratory complications and a 32.8% increased risk of renal complications.[2]

Literature exploring total gastrectomy,[9] hepatic resection[8] and several emergency abdominal surgical procedures[10] found that high BMI carried increased risk of mortality following surgery. For total gastrectomy for stage IV gastric carcinoma, individuals in the obese group had much lower chance of survival than those in the non-overweight group ($P=0.045$). Mortality 2 years post operatively for the overweight group was approximately equal to mortality[5] years postoperatively in the non-overweight group.[9] The findings for hepatic resection and emergency abdominal surgery were similar, with an approximate 50% increased likelihood of mortality in hospital following surgery[8,10] ($P=0.003$).[10] In contrast, studies into vascular surgery, head and neck surgery and laparoscopic hepatectomy all reported either no impact or reduction in risk of 30-day mortality in individuals with high BMI, when compared to a normal BMI control group.[2,4,5,6,7] In some cases this reduction could be as great as mortality being four times less likely in individuals who are obese when compared to a normal control group.[5] Despite compelling evidence that a high BMI could be protective for mortality, risk of significant morbidity was associated with an increasing BMI.[2,4,5,8,9,10] Numerous studies reported longer operative time and increased risk of perioperative complications in patients with high BMI when compared to a control group.[7,9,10] Complications included: greater blood loss during surgery,[9,10] increased risk of pneumonia or other infection,[2,4,8] needing to be reintubated following surgery[5] and liver or renal failure ($P<0.0001$).[8,10] Complications of this nature may go on to have a significant impact on an individual's health and wellbeing. Therefore, they should be considered alongside mortality when assessing an individual's suitability for a surgical procedure.

**Figure 1** compares the 30-day morbidity and mortality rates with BMI class. As BMI class increases so does morbidity. However, mortality tends to decrease outside of the obese III category.[4]

## Discussion

The impact of low BMI on surgical outcomes appears to be well-documented and widely agreed upon.[2,4,5,8] Across the literature that included an underweight (BMI<18) group there was a unanimous increase in mortality compared to a normal control group. In addition to this, the added stroke risk identified following hepatic resection[8] could result in significant disability and reduction in an individual's quality of life. This could then lead to poorer outcomes in the form of reduced independence, inability to complete activities of daily living as well as an increased risk of premature death.

High BMI has been shown to have a largely negative impact on human health and wellbeing, but when it comes to surgical outcomes it is unclear what the impact of BMI truly is. Many studies suggest that a high BMI increases risk,[8,9,10] whilst others suggest that some degree of obesity has a protective effect on 30-day mortality, known as the 'obesity paradox'.[2,4,5,6,7] The 'obesity paradox' is the notion that obesity can reduce the risk of mortality and morbidity in the perioperative period, despite being a risk factor for many other poor health outcomes. This includes increased risk of cardiovascular disease, Type 2 diabetes, musculoskeletal disease such as osteoarthritis and cancer. It is not entirely clear where this protective effect arises from, although there has been a number of theories proposed. These include the idea that individuals with obesity are better nutritionally optimised, specifically relating to the levels of preoperative albumin.[2] Albumin has been shown to have an impact on mortality and morbidity, more specifically hypoalbuminemia is an independent predictor of increased mortality and morbidity following cardiac surgery.[11,12] A meta-analysis into the impact of preoperative serum albumin levels on mortality and morbidity following cardiac surgery evaluated 22,553 patients and found that hypoalbuminemia was associated with an increased risk of mortality of between 66% and 110%. Hypoalbuminemia was also associated with increased rates of complications including congestive heart failure, renal injury, infection, bleeding and atrial fibrillation.[13]

Other explanations include the idea that obese individuals generally have a greater lean body mass and peripheral body fat which could both be protective in the postoperative period. It is also suggested that the paradox could arise from a reduced inflammatory response to the trauma of surgery, or that there is a genetic confounding variable that increases the risk of having high BMI and reduces mortality following surgery.[14]

## Evaluation of literature

There are some limitations to this research, arising from both the literature used and the usefulness of this literature review in isolation. Most of the literature included in this review are retrospective, cohort studies which use data from medical records, introducing selection bias.[5,7,8,9,10] In addition, using medical records can be problematic as there is a risk that documentation is poor, and patient's outcomes were not recorded. It also makes adjusting for confounding more difficult as many potential confounders may not be documented in medical records. This makes proving that BMI is causal of a given surgical outcome challenging. In addition, many of the operations carried out throughout the studies are elective, non-essential procedures where those deemed to be at the highest risk would be excluded from the study group, giving rise to procedural bias.[4,5,7] Many of the studies are also impacted by confounding bias as they only examine the association of one variable with an outcome. For these studies it is possible that other variables such as chronic illness or genetics could play a role in explaining the proposed association.

One of the main limitations with the scope of this review is that surgical outcomes are only one dimension when assessing the overall success, health and wellbeing of a patient following surgery. It does not account for other medical complications, or the psychological and emotional impact surgery may have on a patient, this is especially true for individuals who may have reduced ability to function and complete activities of daily living.

**Table 1** shows all the literature used in this review and the potential biases and limitations identified.

## Implications for further research

Further research into post-operative outcomes, outside of surgery, including medical and psychological complications would be a good next step. This would give a more holistic perspective on overall patient outcome. In addition to this, further research into the physiology that underpins the ‘obesity paradox’ could be clinically significant and may give rise to the idea of physiologically optimising patients of all BMI groups in the preoperative period.

## Conclusion

The impact of BMI on surgical outcomes has proven to be complex. The literature suggests that low BMI has strong evidence to support negative surgical outcomes, both morbidity and mortality. However, in patients with high BMI, whilst the risk of morbidity following surgery seems to mirror that of other disease, such as diabetes mellitus and cardiovascular disease, 30-day mortality unexpectantly appears to decrease as BMI increases. Many theories have been proposed to explain this phenomenon, yet it is clear more research is needed to understand why this occurs. Fully understanding this would prove very valuable to the surgical field and could improve surgical outcomes for many through physiologically optimising patients pre-operatively.



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I am currently a second-year medical student at the University of Bristol and my primary interests are surgery and paediatrics. I have just completed a student selection component in paediatric orthopaedic surgery, where I was able to see the impact research can have on clinical practice. This has left me wanting to deepen my interest in this developing field, both throughout my degree and into my career as a doctor.

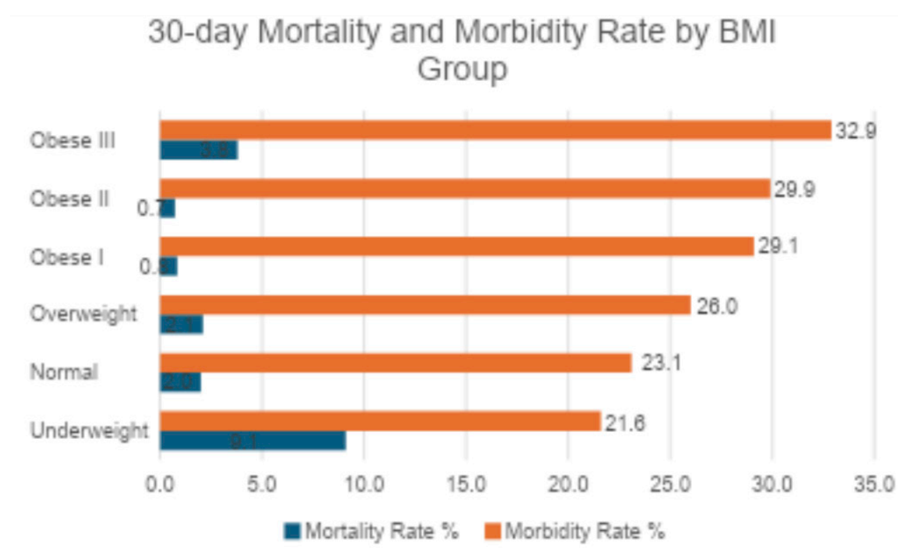


**Figure 1.** Comparing mortality and morbidity rate by BMI group, created using data from Mullen et al 2008[4]

| **Literature** | NHS Digital. (n.d.). *Part 1: Age, time series and sex.* [1] | Davenport, D.L., Xenos, E.S., Hosokawa, P., Radford, J., Henderson, W.G. and Endean, E.D. (2009). The influence of body mass index obesity status on vascular surgery 30-day morbidity and mortality. [2] | Lee, P.H.U. and Gawande, A.A. (2008). The number of surgical procedures in an American lifetime in 3 states [3] | Mullen, J.T., Davenport, D.L., Hutter, M.M., Hosokawa, P.W., Henderson, W.G., Khuri, S.F. and Moorman, D.W. (2008). Impact of Body Mass Index on Perioperative Outcomes in Patients Undergoing Major Intra-abdominal Cancer Surgery [4] | Crippen, M.M., Brady, J.S., Mozeika, A.M., Jean Anderson Eloy, Soly Baredes and Chan, R. (2018). Impact of Body Mass Index on Operative Outcomes in Head and Neck Free Flap Surgery [5] | Zhao, L., Wang, J., Kong, J., Zheng, X. and Yu, X. (2022). The impact of body mass index on short-term and long-term surgical outcomes of laparoscopic hepatectomy in liver carcinoma patients: a retrospective study [6] | Asaad, M., Yao, C., Praneeth Kambhampati, Mitchell, D., Liu, J., Lewis, C.M., Yu, P., Hanasono, M.M. and Chang, E.I. (2022). Impact of Body Mass Index on Surgical Outcomes in Oncologic Microvascular Head and Neck Reconstruction [7] | Mathur, A.K., Ghaferi, A.A., Osborne, N.H., Pawlik, T.M., Campbell, D.A., Englesbe, M.J. and Welling, T.H. (2010). Body Mass Index and Adverse Perioperative Outcomes Following Hepatic Resection [8] | Daisuke Nobuoka, Naoto Gotohda, Kato, Y., Takahashi, S., Konishi, M. and Kinoshita, T. (2011). Influence of excess body weight on the surgical outcomes of total gastrectomy [9] | Kassahun, W.T., Mehdorn, M. and Babel, J. (2022). The impact of obesity on surgical outcomes in patients undergoing emergency laparotomy for high-risk abdominal emergencies. [10] | 11.Engelman, D.T., Adams, D.H., Byme, J.G., Aranki, S.F., Collins, J.J., Couper, G.S., Allred, E.N., Cohn, L.H. and Rizzo, R.J. (1999). Impact of body mass index and albumin on morbidity and mortality after cardiac surgery[11] | Randell, Z., Martin, B., Hendrickson, N., Brodke, D., Spiker, R., Lawrence, B. and Spina, N. (2023). Hypoalbuminemia as a Predictor of Mortality, Disability, and Readmission in Patients Undergoing Spine Surgery [12] | Xu, R., Hao, M., Zhou, W., Liu, M., Wei, Y., Xu, J. and Zhang, W. (2023). Preoperative hypoalbuminemia in patients undergoing cardiac surgery: a meta-analysis [13] | Valentijn, T.M., Galal, W., Tjeertes, E.K.M., Hoeks, S.E., Verhagen, H.J. and Stolker, R.J. (2013). The obesity paradox in the surgical population. [14] |
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| **Identified Biases** | Language bias | Selection bias, Language bias, Confounding bias | None identified | Procedure bias, Language bias, Confounding bias | Selection bias, Proceduel bias, Language bias, Confounding bias | Selection bias, Language bias, Confounding bias | Selection bias, Procedure bias, Language bias, Confounding bias | Selection bias, Language bias, Confounding bias | Selection bias, Language bias, Confounding bias | Selection bias, Language bias, Confounding bias | Confounding bias, Language bias | Language bias, Selection bias, Confounding bias | Language bias | Language bias, Confounding bias |
| **Other Limitations Identified** | Data is on school-aged children. Whilst the rising rate of obesity is consistent between children and adults, it may not be to the exact same extent. | Observational study - makes proving causality difficult. A variety of procedures are included and the results combined - outcomes for each specific operation may be very different from each other. | Study based in the US and could be unrepresentativ e of other populations. The result is an estimate, not an exact number. | Data collected from large institutions, findings may not be generalisable to other institutions. Includes 5 different surgical procedures - the findings may not be representative of other procedures. | Data obtained from medical records - risk of poor documentation and confounding variables may not be recorded. | Data collected from a single centre - results could be affected by the surgeons' strategies. | Data obtained from medical records - risk of poor documentation and confounding variables may not be recorded. Single Institution experience - possible the literature could be unrepresentative of wider populations due to treatment biases of indiviudal practitioners. | Data obtained from medical records - risk of poor documentation and confounding variables may not be recorded. | Data obtained from medical records - risk of poor documentation and confounding variables may not be recorded. | Data obtained from medical records - risk of poor documentation and confounding variables may not be recorded. | Study relies on one parameter to assess nutrional status and does not adjust for potential confounders, such as pre-existing chronic health condition. | Data obtained from medical records - risk of poor documentation and confounding variables may not be recorded. | No further limitaitons identified. | Data is largely collected from Western populations and could be unrepresentativ e of different patient populations. |

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