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Should we use BMI as a selection criterion for bariatric surgery?

Petra Hanson[1,2], Thomas M Barber*[1,2]

[1]Warwick Medical School, University of Warwick, Clinical Sciences Research Laboratories, Clifford Bridge Road, Coventry, CV2 2DX, UK

[2]Warwickshire Institute for the Study of Diabetes, Endocrinology and Metabolism, University Hospitals Coventry and Warwickshire, Clifford Bridge Road, Coventry, CV2 2DX, UK

*Corresponding author:

Thomas M Barber

Clinical Sciences Research Laboratories,

University of Warwick,

University Hospitals of Coventry and Warwickshire (UHCW),

Clifford Bridge Road,

Coventry CV2 2DX,

United Kingdom

E-mail: T.Barber@warwick.ac.uk

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Body Mass Index (BMI) is part of us. We grew up with it. We learnt it. We use it every day. We define obesity by it. We devise guidelines according to it. As such, BMI seems to have acquired an untouchable, almost mythical status since its conception by Quetellet in the 19th Century.

BMI has been in use since 1985 as a clinical tool for patients with obesity following a National Institutes of Health Consensus (1). Use of BMI cut-off values as a selector for bariatric surgery was first introduced in 1991 (2). Despite the widely ubiquitous adoption and apparent acceptance of BMI as a clinically utilitarian variable, BMI is inherently flawed. If we want to understand the nature of obesity, and the inherent flaws associated with BMI as a concept, we need to step outside of the matrix. We need to challenge our own dogmatic beliefs and return to first principles.

The rationale for BMI as a selection criterion for bariatric surgery stems from three fundamental principles. The first of these is that bariatric surgery is a limited resource. This is self-evidently true. Even if the number of bariatric surgical procedures was increased 10-fold, this would still only scrape the surface of the magnitude of the obesity epidemic. As such, bariatric surgery will never be a treatment option for obesity that is truly scalable to the population level. It is entirely appropriate (indeed essential) therefore that we select patients to undergo bariatric surgery.

The second fundamental principle for using BMI as a selection criterion for bariatric surgery is that BMI reflects body fat content. Although this appears to be true for the population (3), BMI is less reliable on an individual level (4). People vary in their muscularity, and sarcopenia is common in the elderly. At the extremes of body habitus, BMI falls apart as a reliable measure of body fat content. Furthermore, given the scaling of body volume with the cubed exponent of height, BMI actually increases linearly with height, thereby introducing inaccuracies in patients at extremes of height (5). However, even if BMI was a perfect measure of body fat content, the cut-offs for defining obesity and the selection criteria for bariatric surgery are entirely arbitrary. Who can define what constitutes ‘excessive adiposity’, a nebulous term that lacks clarity? Furthermore, ‘excessive adiposity’, however we define it is likely to vary between individuals based on biological complexity, and even within the

same individual over time. Additionally, BMI provides no indication of body fat distribution, an important indicator of cardiometabolic risk.

The third fundamental principle for using BMI as a selection criterion for bariatric surgery is that 'excessive adiposity' is harmful to health commensurately, and therefore underlies the co-morbidity of obesity. In other words, the *total amount* of body fat (reflected in BMI) is the best indicator of obesity-related co-morbidity, and therefore the best way to select for bariatric surgery. On a population level, it is broadly true that fat mass does indeed correlate with much obesity related co-morbidity, such as glycaemic control, blood pressure and severity of obstructive sleep apnoea (6, 7). If we extrapolate these population-level association data to the individual however, we run into problems. In fact, on an individual level, body fat content *per se* is actually quite a poor indicator of obesity-related co-morbidity. As alluded to earlier, body fat *distribution* is important, with visceral fat conferring cardiometabolic risk, and gynoid fat even having a cardiovascular protective effect (8). Ectopic fat (hepatic, peri-cardiac and intramuscular) also confers metabolic risk (9). Furthermore, inflammatory status of adipose tissue is associated with insulin resistance and cardiometabolic risk (10). In short, multiple factors other than quantity of body fat influence cardiometabolic risk.

There is inherent complexity in the pathogenesis of cardiometabolic risk that underlies a large proportion of the co-morbidity of obesity. Based on our current evidence, much of this complexity goes far beyond a simple reflection of body fat quantity. Furthermore, there is even evidence to show that improvement in mortality following bariatric surgery appears independent of weight-loss (and therefore BMI reduction) *per se* (11).

It is logical to base selection criteria for bariatric surgery on degree of *individual* cardiometabolic risk, rather than on BMI and total body fat mass *per se*. The Edmonton Obesity Staging System (EOSS) is a clinical tool for obesity that incorporates obesity-related co-morbidities and functional limitations (12). It has been argued that EOSS could be used to select patients for bariatric surgery, although it is acknowledged that it is difficult currently to predict which patients at lower EOSS stages will progress to higher stages over time, and which will remain stable (13). Furthermore, the American Association of Clinical Endocrinologists (AACE) have published recommendations to recognize the need for a more robust and medically meaningful definition of obesity, and for management targets to include weight-related complications and quality of life (14).

In many tier 3 settings within the NHS (National Health Service), multi-disciplinary management of obesity over a prolonged period enables some degree of assessment of suitability and candidacy for bariatric surgery (including clinical, biochemical and psychological factors) that goes beyond BMI. The fact remains however, that despite availability of more refined assessment tools for obesity such

as EOSS (12) and clear recommendations for refinement of definition and management targets for obesity from AACE (14), BMI remains a central pre-requisite for bariatric surgery selection in NICE guidelines and many other guidelines globally, even in cases of obesity-related co-morbidity. Therefore, some patients who should perhaps be eligible for bariatric surgery based on cardiometabolic risk face potential preclusion from this treatment option based on their BMI.

In addition to consideration of current weight-related co-morbidities, refinement of selection criteria for bariatric surgery may also consider future risk of cardiometabolic risk. In a recent study on obese adults (n=474) from Poland, the risk for development of Type 2 Diabetes Mellitus (T2D) was shown to be influenced by serum adiponectin levels, age at onset of obesity and variants within the *TCF7L2* gene (15). In a further study from the same group, it was shown that although early-onset obesity (<age 20 years) was predictive of a higher BMI and total body fat, the risk of development of cardiometabolic complications (including hypertension and T2D) in this group was lower than in those with later, adult-onset obesity (16). Based on these data, perhaps future selection criteria for bariatric surgery should incorporate predictors of cardiometabolic complications that include age of obesity onset, genetic markers and adipokine profiles.

In addition to cardiometabolic risk, selection for bariatric surgery should of course also consider psychological and emotional factors that may have a negative impact on the outcome of bariatric surgery. In one study, there were associations between insomnia, depression, appetite scores and daily consumption of snack foods (17). Whilst our own group did not demonstrate pre-operative psychological (and quality of life) factors as significant predictors of weight-loss following gastric band insertion (18), future studies on pre-operative predictors of outcome following bariatric surgery should further explore this area, and include measures of sleep quality and sufficiency, given the known effects of sleep duration on appetite control (19). Future guidelines on selection criteria for bariatric surgery should perhaps provide greater emphasis on psychological, emotional and lifestyle predictors of outcome: such guidance would also serve as means to optimize such factors prior to selection for bariatric surgery.

Finally, further research should focus on development of future biomarkers for obesity-related cardiometabolic risk, and their potential utility as possible selection criteria for bariatric surgery. Based on current evidence linking inflammatory status within adipose tissue and association with T2D and cardiometabolic risk (10), clinically available and reliable biomarkers of adipose tissue inflammation would be of potential interest. Furthermore, given the central role of cardiorespiratory fitness as a determinant of cardiometabolic risk (20), development of clinically accessible and reliable biomarkers of cardiorespiratory fitness would have clinical utility. Although speculative, it is

possible that such measures of cardiorespiratory fitness could inform candidacy for bariatric surgery based on cardiometabolic risk, although this would require supportive evidence prior to guideline implementation.

Perhaps one reason for the persistence of BMI as a selection criterion for bariatric surgery stems from its utility on a *population* level as a measure of body fat mass (3). From the perspective of policy-makers and guideline-drafters, BMI therefore may appear to have utility as a means of stratifying the populace, based on population-wide body fat mass and therefore perceived need. However, future guidelines for bariatric surgery should move beyond BMI, and consider the wider picture from the clinical needs of the individual patient perspective, rather than from a populace viewpoint. In re-defining eligibility for bariatric surgery, we may also transform the way we think about obesity and its importance as a clinical entity. Not so much as a condition of excessive adiposity, but as a condition with weight-related (primarily cardiometabolic) comorbidities centre stage.

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