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Limitations of body mass index as an obesity measure of perioperative risk

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The prevalence of obesity is rapidly increasing around the world. It is generally believed that overweight and obese individuals are at greater risk of many complications after surgery, but most perioperative studies have found that this is not the case.^{1–3} In fact, mildly obese and overweight patients tend to have better survival rates than normal weight patients after many types of surgery,^{4–9} despite some evidence of increased surgical site and other infections,^{1 2 7 10–12} blood loss,^{7 12} acute kidney injury,¹³ and perhaps other complications.¹⁴ Over the last decade or so, this ‘obesity paradox’,⁶ has also been reported in medical conditions such as coronary artery disease, heart failure, peripheral arterial disease, hypertension, stroke, and renal failure.¹⁵

A recent prospective cohort study that enrolled 4293 patients undergoing general surgery measured the association between body mass index (BMI) and postoperative morbidity and mortality.⁷ Obese patients (BMI >30 kg m⁻²) were compared with underweight (BMI <18.5 kg m⁻²), normal weight (BMI 18.5–25 kg m⁻²), and overweight (BMI 25–30 kg m⁻²) patients. Longer-term survival was measured with a median follow-up time of 6.3 years. Although obese patients had a higher incidence of postoperative surgical site infection, adjusted analysis demonstrated that underweight patients had worse survival [hazard ratio (HR) 2.1 (95% CI 1.4, 3.0)], whereas overweight [HR 0.6 (95% CI 0.5, 0.8)] and obese patients [HR 0.7 (95% CI 0.6, 0.9)] had improved survival. This study demonstrates the obesity paradox in a perioperative setting. Obesity defined by BMI is not a major risk factor in general surgery.

The measure of obesity in nearly all of the above studies has traditionally been BMI. However, given that the body fat increases and muscle mass decreases with age,¹⁶ changes in height, weight, and BMI may not correspond to proportional changes in body fat or muscle mass. The clinical utility of BMI could be questioned because it does not accurately reflect visceral fat accumulation, the likely culprit leading to most of the metabolic and clinical consequences of obesity.^{17–21} There is also a growing recognition of a ‘metabolically healthy’ obesity state,²² in which some individuals are free from the metabolic complications of obesity, most likely because of less visceral fat and preserved insulin sensitivity.^{22 23}

Although BMI is ideally suited for population-level studies, describing obesity by BMI can result in inaccurate assessment of adiposity, because the numerator in the calculation of BMI does not distinguish lean muscle from fat mass.¹⁸ Thus, a person with central obesity (with excessive visceral fat) can have a normal BMI and yet will have a high mortality risk.²⁴ BMI does not take sex differences in the distribution of fat or age-related decline in muscle mass into consideration. Moreover, BMI studies based on self-reported measurements and retrospective data from chart reviews are imprecise.²⁵ A good illustration of some of these points can be found in the results of the INTER-HEART study, which enrolled >27 000 participants from 52 countries and found that BMI had only a modest association with myocardial infarction; this was not significant after adjustment for other risk factors.²⁶ In contrast, adiposity measurements such as waist:

hip ratio (WHR) and waist circumference were strongly associated with cardiac events, even after adjustment for other risk factors. This compelling evidence shows that regional fat distribution may be critical in determining the cardiovascular risk associated with obesity.²⁶

So, are there better ways to measure obesity, and if previous perioperative studies were based on a misleading obesity metric, do we need to revisit perioperative risk evaluation of obese individuals?

Fat distribution differs between individuals and may be responsible for different risk factor profiles in equally obese individuals.¹⁹ In essence, body fat can be stored either as subcutaneous fat that acts as a metabolic sink or as visceral fat, which gives an indication of a person's metabolic risk profile.^{18, 19} The recently reported concept of 'normal weight obesity' and its association with high mortality risk in patients with cardiac disease²⁷ suggests that other adiposity measures, alone or in combination with BMI, may be more appropriate to determine perioperative risk.^{28, 29} Obesity measures other than BMI have a stronger correlation with postoperative complications.^{30, 31}

Other relatively simple methods of measuring body fat include the WHR, waist circumference, skinfold thickness, and bioelectrical impedance analysis³²; more sensitive but costly measures include computed tomography, dual-energy X-ray absorptiometry, and magnetic resonance imaging.³³ Of these, both waist circumference and WHR seem to be useful measures of adiposity in the perioperative setting,³¹ particularly given that central obesity is a good surrogate of visceral fat accumulation and metabolic risk syndrome.³⁴ Waist circumference is strongly associated with metabolic risk and increased morbidity and mortality from type 2 diabetes and cardiovascular disease independent of the effect of BMI,^{17, 21} and has a stronger association with visceral adiposity than WHR.^{20, 35} But WHR is not a specific indicator of abdominal visceral fat accumulation.³⁵ Moreover WHR, like BMI, is a ratio metric that will be high in individuals with a large waist or narrow hips.¹⁸ With the contrasting effects of upper and lower body fat on cardiovascular disease risk factors,³⁶ WHR values could be hard to interpret. Consideration of all of the above features suggests that quantification of obesity using measurement of waist circumference could solve the mystery of the obesity paradox.

The main drawback of waist circumference seems to be its lack of ability to differentiate subcutaneous from visceral fat deposition.²⁰ In addition, body composition varies with age, sex, and ethnicity, and there are insufficient normative sex- and age-specific data that would define obesity. But with these caveats in mind, we conclude that waist circumference would be a better measure of obesity risk in the perioperative setting.

Author's contributions

Conception and writing of the first draft of the manuscript: U.G. Critical revision of the manuscript and additional intellectual content: P.M.

Final approval of the manuscript: U.G., P.M.

Declaration of interest

None for all authors.

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The increasing recreational use of nitrous oxide: history revisited

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Nitrous oxide (N₂O) is used in the food industry as a mixing and foaming agent (E942) in the production of whipped cream,^{1,2} and as a fuel booster in the motor industry.³ It is also a familiar agent in obstetric, dental, emergency, and anaesthetic practice, where use is made of its analgesic and anaesthetic properties. However, nitrous oxide was used recreationally long before its medical potential was realized. Joseph Priestly is accredited with first synthesizing the gas in 1772,³ and by the late 18th century inhalation of nitrous oxide became a popular public entertainment.⁴ The gas became a fashionable addition to British high-society parties in the early 1800s thanks to its euphoric and relaxant properties, which led chemist Humphrey Davy to coin the term 'laughing gas'.³

Although the routine use of nitrous oxide in anaesthesia is declining in both the UK⁵ and internationally,⁶ there has been a recent resurgence of recreational use of the gas. Its presence is now commonplace at festivals and university parties,⁴ with a surprisingly high 7.6% of 16- to 24-yr-olds responding to the 2013/14

Crime Survey for England and Wales reporting nitrous oxide use in the preceding year.² This is a greater proportion than had used cocaine, ecstasy, or ketamine.⁴ Despite this, it is our impression that many anaesthetists and emergency department doctors are unaware of the scale of nitrous oxide use in the community.

The product is freely available from catering outlets, street vendors, and even via home-delivery service through the Internet or mobile vans advertising nitrous oxide for sale in UK cities. For recreational use, nitrous oxide is commonly sold in prefilled balloons (at point of use) or small pressurized metal canisters (Fig. 1) designed for the food industry. A standard catering canister containing 8 g of nitrous oxide in a volume of 10 cm³ can be bought for as little as £2,⁷ and produces the equivalent of ~8 litres of nitrous oxide gas at standard temperature and pressure.⁸ The pressurized gas is released into balloons using either a puncturing device, called a charger, or equipment designed to produce whipped cream.^{2,8} Once a user inhales from a balloon, the partial