The evolving concepts in visceral obesity: What anesthesiologists need to know

ABSTRACT

Obesity, an ever-evolving global epidemic, continues to offer some of the most controversial and at times, polarizing debates in the modern-day medicine; whether it is for the formers' ethnic intricacies, or for that matter, its potential outcome associations. Given the far-reaching implications of obesity however, the recent developments in characterization of the same, are of special interest to an anesthesiologist caring for this predilected cohort of patients. The expert propositions, in this regard, outline the much-required need to think beyond the body mass index (BMI), traditionally used to define obesity. To that effect, motivated by the understanding of obesity as an adiposity-based chronic disease, visceral obesity has gained particular attention with the cost-effective and adaptable anthropometric measures: waist circumference, waist-to-hip ratio, and of late waist-to-height ratio, outperforming the isolated predictive and prognostic utility of BMI in the corresponding literature. Moreover, it is for the concept of visceral obesity that may aid in the distinction of metabolically unhealthy obesity from the metabolically healthy obesity. Hence, focusing the evolving updates on visceral obesity, the index narrative review comprehensively discusses the topic, underlining the points relevant to anesthesiologists, such as cardiometabolic risk profiling, relationship to metabolic syndrome, metabolic inflammation, operative outcomes, the perplexity surrounding "obesity paradox," and the useful insights provided by critical care medicine and the viral pandemic.

Key words: Adiposity, body mass index, cardiometabolic risk, obesity, visceral obesity, waist circumference, waist-to-height ratio

Background

There continues to be a steady increase in the worldwide burden of obesity, indeed not overstated if called upon as an evolving global epidemic. Focusing future trajectories for the Global Burden of Disease Study 2021, a thought-provoking article published in "*The Lancet*" in the year 2025, reveals concerning global-, regional-, and national-trends on the prevalence of overweight and obesity in the adult population, with the forecasts extending up to 2050.[1]

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Alongside epidemiology, the clinical concerns relating to the former become manifold when the multifaceted metabolic predisposition happens to be centered around obesity, as the pivotal player.[2] The anesthesiologists, in this regard, are often faced with unique perioperative challenges emanating as a consequence of obesity in their patients.[3]

Obesity and Anesthesia: *a subject of perpetual research interest!*

Given the pertinent clinical implications, obesity has been a subject of perpetual research interest, in reference to the perioperative literature.[3-5] It is interesting to witness that a PubMed database search as of date on: "obesity" AND "anaesthesia," demonstrates a considerable rise in the number of articles published in the topic, over the last 6 decades, through the period from 1965 to the present, as illustrated in the Figure 1.

To be specifically noted here, the concept of visceral obesity has, of late, been increasingly recognized, mandating point-by-point elaboration, backed by the corresponding literature, both from a generalized and a specialized perspective of the anesthesiology fraternity.[6-10]

Search Strategies

This nonsystematic review was planned after a comprehensive analysis of the available literature from textbooks, journals and the internet sources surrounding a constellation of keywords: "Adipose tissue," "Adipose tissue dysfunction," "Adiposity," "Anthropometry," "Body mass index," "Cardiometabolic risk," "Obesity," "Visceral adiposity," "Visceral obesity," "Waist circumference," "Waist-to-height ratio," and "Wasit-to-hip ratio." As for the literature search, the MEDLINE content was retrieved via PubMed to be expanded by search engines such as Scopus, EMBASE, Google Scholar, Science Direct, and others, to collate the requisite scientific content of relevance to the subject.

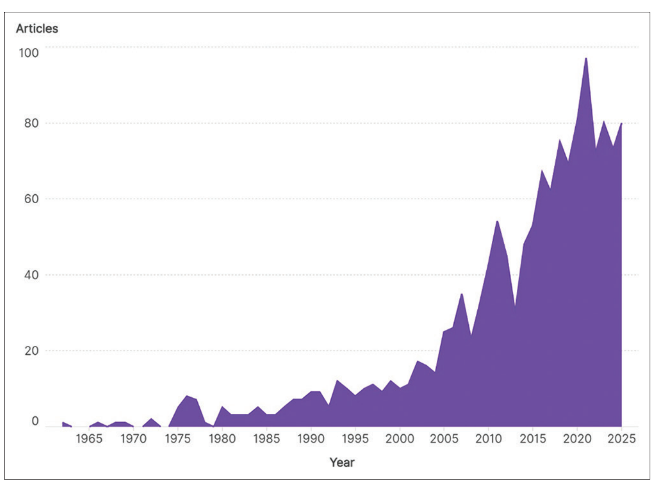

Figure 1: The yearly trends of publications discovered on a PubMed database search as of date on: "obesity" AND "anaesthesia", spanning from 1965 to 2025

Characterizing Obesity: *the need to think beyond BMI!*

Obesity has conventionally been characterized, utilizing the body mass index (BMI), estimated as the body weight in kilograms by height in meters squared, i.e., kg/m^2.[11] However, the limitations pertaining to the use of BMI for defining obesity have gained impetus, more than ever before, in the current era of precision medicine.[11-13] Given that the numerator in the BMI computation fails to distinguish lean muscle from fat mass, the capture of individual-level adiposity-related risk assessment is curtailed.[11,13] To that effect, the accuracy of BMI in reflecting the visceral fat accumulation, or for that matter, the pattern of body fat distribution, is questionable, the same being at the cornerstone of the metabolic sequelae of obesity.[13,14]

There happens to be two distinct and equally important ways of looking at this. First, with the recognition of a "metabolically healthy" state of obesity, individuals can be rendered at an attenuated risk in the backdrop of a lower amount of visceral fat and, thereby, preserved insulin sensitivity.[15] On the other hand, an accentuated risk can be associated with an individual with central obesity or excessive visceral fat, despite BMI falling in the normal range.[16]

Perioperative physicians, aiming at sound risk-stratification, while caring for their obese surgical subset, need to take into consideration the recent propositions on the topic. The European Association for the Study of Obesity (EASO) outlines a revised diagnostic framework to characterize obesity as: *"BMI ≥30 Kg/m^2 or BMI ≥25 Kg/m^2 and a waist-to-height ratio (WtHR) ≥0.5 with medical-functional-psychological impairments or complications."*[6] The refined algorithm, bespeaking the pivotal role of anthropometric screening for high-risk fat accumulation, emanated from a consensus process by conducting a modified Delphi study involving 29 experts, generating an assorted set of diagnostic-staging-management statements conceptualizing obesity as an adiposity-based chronic disease (ABCD).[6,17]

The concept of ABCD has been duly emphasized in the 2025 Spanish GIRO: "Guía española del manejo Integral y multidisciplinaR de la Obesidad en personas adultas" guidelines, as well.[17]

Visceral Fat: *same-same but different!*

The regional depots of adipose tissue function as specialized endocrine organs with peculiar biological functions. Meanwhile, the subcutaneous adipose tissue is believed to be a "protective metabolic sink," the visceral adipose tissue, instead, is linked to peculiarly different biological functions.[13,18]

These factors, as enumerated in Table 1, point toward the potential association of the visceral adipose tissue with insulin-resistance, hypertriglyceridemia, and an elevated circulating free fatty acids (FFA), contributing to an adverse metabolic profile alongside relating to elevated adipokine-cytokine secretion, inflammatory mediators, and a proinflammatory milieu, represented by macrophage infiltration.[18,19] It remains to be highlighted here that the FFA spillover owing to heightened lipolysis results in redistribution to other nonadipose organs as ectopic fat deposition, a forerunner of lipotoxicity [Table 1].[20]

The Measures of Visceral Obesity: *a closer look!*

Adipose tissue assessment can be performed by computed tomography (CT), magnetic resonance imaging, or with dual-energy X-ray absorptiometry (DXA), especially for the ability to differentiate visceral from the subcutaneous fat, wherein other cost-effective modalities like ultrasound and bioelectrical impedance analysis are gaining concurrent attention.[18]

Anthropometric estimations, nonetheless, require elaboration, especially in the light of the recent expert statements. The waist circumference (WC), waist-to-hip ratio (WHR), and sagittal abdominal diameter, serving as simple, reproducible measurements here; WtHR (as mentioned above) feature in the EASO refined diagnostic framework alongside a 96% degree of consensus agreement on the estimation of WC in an individual with a BMI <35 kg/m^2 as a sign of visceral fat accumulation and elevated cardiometabolic risk.[6,19] A commission of experts publishing their extensive recommendations in "*The Lancet Diabetes and Endocrinology*" (2025), on the revision of basic concepts defining obesity, restate the contextual importance of adiposity.[21] The commission affirms with a 98% grade of agreement that clinical obesity assessment requires the confirmation of excess adiposity by (i) direct body-fat estimation (DXA, bioimpedance, etc.), (ii) at least 1 anthropometric criterion (WC, WHR, or WtHR) in addition to BMI, or (ii) at least 2 anthropometric criteria (WC, WHR, or WtHR)) regardless of the BMI.[21]

Table 1: The biological and functional peculiarities of visceral adipose tissue[18-20]

- An increased number of large adipocytes, which are insulin-resistant.
- Drained through the portal vein, potential alteration of the hepatic metabolism.
- Heightened lipolysis leading to an augmented circulating FFA.
- Further accentuated sensitivity to catecholamine-induced lipolysis.
- Principal driver for the development of an adverse metabolic profile.
- Relates to endocrine dysfunction and an atherogenic state.
- Leads to a disturbed balance in favor of a proinflammatory milieu.
- Adipose hypertrophy associates with diminished angiogenesis and tissue hypoxia.
- Excess FFA deposit as ectopic omental-epicardial fat or in other nonadipose tissues.
- Linked to age, sex, ethnicity, genetics, hormones, diet, nicotine, and physical activity.

FFA=Free fatty acids

The corresponding anthropometric cut-offs commonly described in the literature are as follows[22]:

- **Abnormal WC:** ≥35 inches, i.e., 88 cm in women and ≥40 inches or 102 cm in men (most Asian cohorts, WC ≥31.5 and ≥35 inches, i.e. 80 and 90 cm in respective women and men).
- **Abnormal WHR**: ≥0.85 (women) and ≥0.90 (men).
- **Abnormal WtHR**: ≥0.50.

Of note, Yang *et al*.,[23] in their 2025 cross-sectional study involving 3,371 participants, validate the EASO criterion for diagnosing visceral obesity, depicting strong correlations between WC and WtHR with visceral fat area (VFA) calculated on CT. Meanwhile, BMI in combination with WC emerged to be the most effective for diagnosing visceral obesity in their Chinese population, the debates surrounding the WtHR cut-offs in relation to ethnicity, have picked momentum.[23-25] This seems to be having an analogy with the World Health Organization (WHO) BMI cut-offs being improvised to the ethnic context.[26] Itani and Ghoch[24] hypothesize that the EASO WtHR cut-off ≥0.5 happens to be low for those overweight as per the WHO criterion (BMI ≥25 but <30 kg/m^2). They derive the following WtHR cut-offs to have the highest discriminative ability for central obesity, across different ethnic groups employing the data from the National Health and Nutrition Examination Survey (NHANES) of the noninstitutionalized adult United States population: 0.57 and 0.58 for White males and females, 0.55 and 0.57 for Black males and females, 0.56 and 0.59 for Asian males and females, and 0.57 and 0.59 for Hispanic males and females.[24] In addition to the population characteristics and sex, the EASO WtHR cut-off has been interrogated in context with the patient height.[6,27] Rangel-Baltazar *et al*.[27] discover higher WtHR cut-offs as predictors of cardiovascular risk in short stature people as opposed to those with a normal stature, reiterating that the existing cut-off may unfairly classify the short heighted, to be at-risk.[28]

Composite indices and scores have simultaneously been developed to quantify the metabolic risk involved. The indices feature, the visceral adiposity index (VAI, estimated using BMI, WC, triglyceride, and the high-density lipoprotein) and the combined adiposity-nutritional index or the CANI, computed using the VAI and prognostic nutritional index (PNI), which in turn includes the serum albumin, and the total lymphocyte counts.[19,29,30] Furthermore, given the association of adipose tissue dysfunction with insulin resistance, Bello-Chavolla *et al*.[31] develop the Metabolic Score for Visceral Fat (METS-VF) score, combining the age, sex, WtHR, and the noninsulin-based METS-IR index (a novel index considering fasting glucose, lipid levels, and BMI).[32]

Relevant Literature: *underlining the points of interest for an anesthesiologist!*

This section of the review deals with the relevant literature in the subject of visceral obesity, of potential interest to an anesthesiologist, under the heads relating to cardiometabolic risk, metabolic syndrome, inflammation, operative outcomes, paradox perplexity, and critical care, including coronavirus disease 2019 (COVID-19), as displayed in Figure 2.

(i) An improved cardiometabolic risk profiling.

Buttressing the role of central obesity, a systematic review and meta-analysis by Ashwell *et al*.[33] depict the superiority of WtHR over BMI and WC for mapping the cardiometabolic risk. Out of a total of 31 eligible studies with over 3,00,000 adults from various ethnic groups, WtHR could improve adverse-outcome discrimination by 4–5% over the BMI ($P < 0.01$) with the WC, improving the discriminatory power by 3% ($P < 0.05$) over BMI, where WtHR proved better than the WC for defining the cardiovascular risk.[33] Even in a large database result from NHANES, the indicators of fat distribution correlated with the DXA findings, propounding the need for assessing fat distribution in conjunction with BMI to characterize obesity.[11]

The year following the EASO obesity diagnostic criterion, Liu *et al*.[34] validate the former, outlining its significant association with all-cause, cardiovascular disease-related and cancer mortality with hazard ratio; 95% confidence interval (CI) of 1.13; 1.02–1.24, 1.48; 1.20–1.83, and 1.26; 1.03–1.54, respectively. While a simple value for WtHR of 0.5 identified early health-risk associated with central obesity better than a complex matrix utilizing BMI and WC in an independent study[35]; Wang *et al*.[36] delineate a U-shaped relationship of WtHR with all-cause mortality, providing for a relatively stable cutoff value of 0.58 for mortality in relation to obesity-linked diseases. An editorial by Chan and Lo[37] appropriately sums it up by calling out the population with normal WC, however, with elevated WtHR, as an overlooked cohort while profiling the cardiometabolic risk.

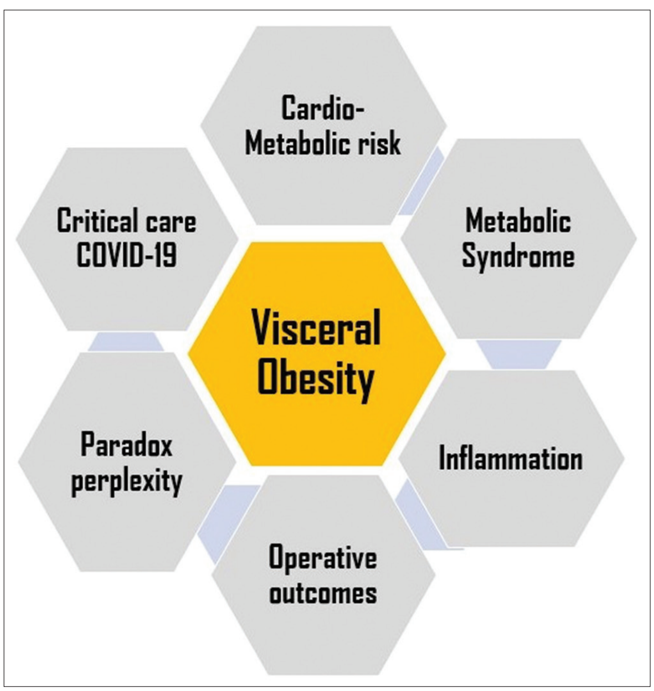

Figure 2: Visceral obesity and the anesthesiologist

(ii) Relationship with the Metabolic Syndrome (MetS).

MetS, is often used to describe a set of metabolic abnormalities: abdominal obesity, elevated glucose and blood pressure, high triglycerides, and reduced high-density lipoprotein.[38] The relationship between metabolic health and obesity might not be as simple as believed to be. Acknowledging that the obese subset can be categorized into metabolically healthy and metabolically unhealthy obesity, even normal-weight individuals may develop MetS, again underlining the role of visceral adiposity.[29] Sun *et al*.[39] show an independent positive association of VFA with the risk of MetS in individuals with normal weight. As for the anthropometric measures, a systematic review and meta-analysis by Chan *et al*.[38] reveal an improved performance of WtHR when compared to WC and BMI, for the screening of MetS in older adults.

(iii) Metabolic inflammation or metaflammation.

Adipose tissue dysfunction is marked by adipocyte hypertrophy, ectopic fat deposition, and the infiltration of immune corpuscles.[40] Visceral adipose tissue inflammation has been labeled as the significant most correlate of metabolically unhealthy obesity.[40] It is this obesity-associated low-grade chronic inflammation and the resultant metabolic disturbances that have been coined as "metaflammation."[41] Hardy *et al*.[42] associate BMI-independent inflammation in the omental adipose tissue with insulin resistance in the obese. Speaking of the perioperative perspective, Okamura *et al*.[43] suggest visceral obesity to promote the postoperative inflammation after minimally invasive esophagectomy. Related findings have also been outlined by Conti *et al*.[44] and Doyle *et al*.[45] in diverse surgical settings, reiterating that the viscerally obese are prone to experiencing an enhanced inflammatory response postoperatively.

(iv) Perioperative outcome, as it matters the most.

Literature exists to link obesity correlates, apart from the BMI, with postoperative outcomes.[46,47] Gordon *et al*.,[8] having discovered significantly higher WC amongst post-total knee arthroplasty (TKA) patients developing Clavien-Dindo IV complications (112.4 cm vs 110.5 cm, $P < 0.001$), reveal each cm increase in the WC to be associated with a post-TKA complication with an odds ratio (OR) of 1.11, $P < 0.001$). Much on the same lines as the importance of central obesity, Jain *et al*.[9] prospectively outline WHR as a superior predictor of the surgical risk when compared to the BMI of patients undergoing breast reconstruction.

As for the perioperative role of WtHR, the latter emerged as an independent predictor of postoperative fibrillation (PoAF), on the multivariate analysis of data emanating from 255 coronary artery bypass grafting (CABG) patients (OR: 1.068; 95% CI: 1.032–1.105, $P < 0.001$).[48] Even for recovery following anesthesia, WtHR outperformed BMI, WC, and WHR in a study by Cao *et al*.,[10] involving an operative subset of benign breast tumors subjected to surgical intervention.

Pertinent literature is hereby discussed from the cardiac and the noncardiac operating room, focusing on some of the commonly performed procedures in the respective settings.[30,49-51] Ahead of Engin *et al*.[49] delineating the PoAF predictive significance of an increased VAI and a reduced PNI in on-pump CABG patients, Bansal *et al*.[30] show CANI (VAI/PNI) to predict major adverse cardiac and cerebral events following off-pump CABG. With regard to the noncardiac procedures, alongside WC emerging to be a predictor of surgical difficulty in laparoscopic cholecystectomy in a cross-sectional 2025 study[50]; another study by Hashemian *et al*.[51] published this year implicated abdominal obesity with the pain intensity after laparoscopic surgeries.

Systematic literature also has interesting findings to put forth in this reference. Saravana-Bawan *et al*.[5] analyzed the data accrued from 19 studies to not suggest any significant difference in the 30-day mortality or overall postoperative complications between the patients with visceral obesity as opposed to those with normal VFA. However, their analysis did demonstrate an important association between the former and accentuated risk of surgical site infection, and the propensity to develop pneumonia, and pancreatic fistula, postoperatively.[5] Dwelling upon the above discussed potential relationship of visceral obesity with MetS, a systematic review and meta-analysis by Norris *et al*.[52] deserves mention to have had involved 13 million participants, to eventually attribute a moderately elevated risk of surgical complications in the background of MetS.

(v) Paradox, related to the orthodox approach?

Despite various pathophysiological explanations being put forth to support the "obesity paradox," there continues to be a considerable debate as to whether it is a true effect or a methodological artefact.[53,54] Moreover, literature exists to raise doubts regarding the likelihood of the fraternity dealing with a "BMI paradox" instead of an "obesity paradox" and it is the fat distribution that more appropriately determines the allied risk and the outcomes.[55] As an exemplar, studies have revealed that a population group at a given BMI, nonetheless, with higher visceral adipose tissue than another population group, manifests an elevated metabolic burden and complications thereof.[56-58] The rather weak correlation of BMI with the visceral adipose tissue also supports that the paradox may be related to the orthodox approach of characterizing obesity with BMI, in isolation.[59]

(vi) The insights offered by critical care and COVID-19.

A recent review by Ralston *et al*.[19] extensively discusses the role visceral adiposity plays, in relation to outcomes in the critically ill, for instance, in those with sepsis and acute respiratory distress syndrome. The author group additionally elucidates that an increased visceral adipose tissue detrimentally impacts the outcomes in patients with acute pancreatitis.[19] Having said that, aligned with the pivotal prognostic ramifications of metabolic players in the ever-so baffling viral pandemic,[60] Malavazos *et al*.[61] associate an abdominal obesity phenotype with higher chest X-ray severity scores, better than the obesity defined with BMI, in a subset of hospitalized patients ailing from COVID-19.

Future Directions and Conclusion

Visceral obesity is an important clinical entity that needs to be carefully accounted for, with cost-effective and adaptable estimates. The index narrative review article, by no means a complete representation of the diverse quantitative and qualitative aspects pertaining to visceral obesity, serves as a primer to what anesthesiologists should know about all that is evolving in this dynamic field. At the same time, it does blow out a clarion call for more focused research in the subject, aimed at providing some valuable answers to the incessant questions that this intriguing syndrome has been asking the medical fraternity for quite some decades now.

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Conflicts of interest

There are no conflicts of interest.

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