

Morbid Obesity's Silver Lining: An Armor for Hollow Viscus in Blunt Abdominal Trauma

Chih-Yuan Fu^{1,2} · Francesco Bajani¹ · Caroline Butler¹ · Stanley Welsh¹ · Thomas Messer¹ · Matthew Kaminsky¹ · Frederick Starr¹ · Andrew Dennis¹ · Victoria Schlanser¹ · Justin Mis¹ · Stathis Poulakidas¹ · Faran Bokhari¹

Published online: 26 November 2018
© Société Internationale de Chirurgie 2018

Abstract

Background Morbid obesity is usually accompanied by both subcutaneous and visceral fat accumulation. Fat can mimic an air bag, absorbing the force of a collision. We hypothesized that morbid obesity is mechanically protective for hollow viscus organs in blunt abdominal trauma (BAT).

Methods The National Trauma Data Bank (NTDB) was queried for BAT patients from 2013 to 2015. We looked at the rate of gastrointestinal (GI) tract injuries in all BAT patients with different BMIs. A subset analysis of BAT patients with operative GI tract injuries was performed to evaluate the need for abdominal operation. Multivariate analyses were carried out to identify factors independently associated with increased GI tract injuries and associated abdominal operations.

Results A total of 100,459 BAT patients were evaluated in the NTDB. Patients with GI tract injury had a lower proportion of morbidly obese patients [body weight index (BMI) ≥ 40 kg/m²] (3.7% vs. 4.2%, $p = 0.015$) and instead had more underweight patients (BMI < 18.5) (5.9% vs. 5.0%, $p < 0.001$). The risk of GI tract injury decreased 11.6% independently in morbidly obese patients and increased 15.7% in underweight patients. Of the patients with GI tract injuries ($N = 11,467$), patients who needed a GI operation had a significantly lower proportion of morbidly obese patients (3.2% vs. 5.3%, $p < 0.001$). The risk of abdominal operation for GI tract injury decreased 57.3% independently in morbidly obese patients. Compared with underweight patients, morbidly obese patients had significantly less GI tract injury (6.0% vs. 13.3%, $p < 0.001$) and associated abdominal operation rates (65.2% vs. 73.3%, $p < 0.001$).

Conclusion Obesity is protective in BAT. This translates into lower rates of GI tract injury and operation in morbidly obese patients. In contrast, underweight patients appear to suffer a higher rate of GI tract injury and associated GI operations.

The paper will be presented in the Scientific Forum program at the American College of Surgeons' Clinical Congress, October 21–25, 2018 in Boston, MA. (ID #73951).

✉ Faran Bokhari
fbokhari2000@yahoo.com

Chih-Yuan Fu
drfu5564@yahoo.com.tw

Francesco Bajani
francescobajani@hotmail.com

Caroline Butler
caroline.butler@cookcountyhhs.org

Stanley Welsh
sjwelsh3@gmail.com

Thomas Messer
tmesser@cookcountyhhs.org

Introduction

The prevalence of obesity is rising rapidly in the USA and other industrialized nations. Approximately one-third of the US adult population is obese [1–3]. Obesity is a major public health problem and is associated with a number of medical problems and surgical complications [4–7]. Morbid obesity [body weight index (BMI) ≥ 40 kg/m²] is especially thought a poor sign for patients' outcomes [8, 9].

Morbid obesity is usually accompanied by both subcutaneous and visceral fat accumulation. Fat can mimic an air bag, absorbing the force of a collision. Thick subcutaneous and visceral fat might prevent injury to intra-abdominal organs. We hypothesized that morbid obesity is a protective mechanism in blunt abdominal trauma (BAT). The literature describes the “obesity paradox” as low mortality in patients with high BMI due to their better nutrition status, low-grade inflammatory response and macrophages linked with adipocytes [10–12]. However, there are few reports which discuss the cushion effect of obesity in preventing injury.

Solid organs and the gastrointestinal (GI) tract are surrounded by omentum and mesenteric fat. The relationship between morbid obesity and GI tract injury in BAT patients was evaluated in the current study. We tried to delineate the characteristics of patients with GI tract injury and the role of morbid obesity in BAT patients. In patients with GI tract injuries, individuals who received abdominal operations were compared with those who did not. Two extreme groups (morbid obesity vs. underweight patients) were also compared to find support for our fat cushion theory.

Matthew Kaminsky
MKaminsky2@cookcountyhhs.org

Frederick Starr
fstarr@cookcountyhhs.org

Andrew Dennis
adennis@cookcountyhhs.org

Victoria Schlanser
vmoscaredelli@gmail.com

Justin Mis
Justin.Mis@cookcountyhhs.org

Stathis Poulakidas
spoulakidas@cookcountyhhs.org

¹ Department of Trauma and Burn Surgery, Stroger Hospital of Cook County, Cook County Health and Hospital System and Rush University, 1950 West Polk Street, 8th floor, Chicago, IL 60612, USA

² Department of Trauma and Emergency Surgery, Chang Gung Memorial Hospital, Chang Gung University, Taoyuan, Taiwan

Methods

The National Trauma Data Bank (NTDB) was queried for BAT (ICD-9: 863–869) patients from July 1, 2012, to June 30, 2015. Patients with penetrating trauma, burn or unknown mechanisms, missing key values, calculated BMI < 15 or > 50 were excluded. Data for BMI and abdominal operations were collected and evaluated.

We looked at the rate of GI tract injuries in all BAT patients with different BMIs. Patients with and without GI tract injury were compared to evaluate characteristics of GI tract injury patients in BAT. A subset analysis of BAT patients with operative GI tract injuries was performed to evaluate the need for abdominal operation among patients with different BMIs. Logistic regression analyses were carried out to identify independent factors and the associated odds ratios of the above comparisons. Patients who were underweight (BMI < 18.5) and those with morbid obesity were compared to evaluate the rate of GI tract injury and the associated need for abdominal operations between these two extreme groups. The current study was approved by the Institutional Research Board of our institution. (Ref No. 18-073X)

Statistical analysis

In the current study, all the original files of NTDB with the target data were merged and analyzed with R (V3.3.1). Nominal data are presented as a percentage and were compared using the Chi-square test, and numerical data are presented as the mean and standard deviations and are compared using the student's *t* test (ISS was presented as the median and interquartile range). A value of $p < 0.05$ was considered statistically significant. Logistic regression analysis was used to adjust for factors which might affect GI tract injury and concomitant operations. Microsoft Excel (V16.13.1) was used for data entry and to draw associated figures.

Results

During the 3-year study period, 100,459 BAT patients were evaluated in the NTDB with a mean BMI of 27.1. There were 11,467 (11.4%) patients with GI tract injury, and 8752 (76.3%, 8752/11467) of them received abdominal operations. Overall GI injury rate decreased with increased BMI (Fig. 1). As expected, abdominal operation rates also decreased with higher BMIs in patients with GI tract injury (Fig. 2).

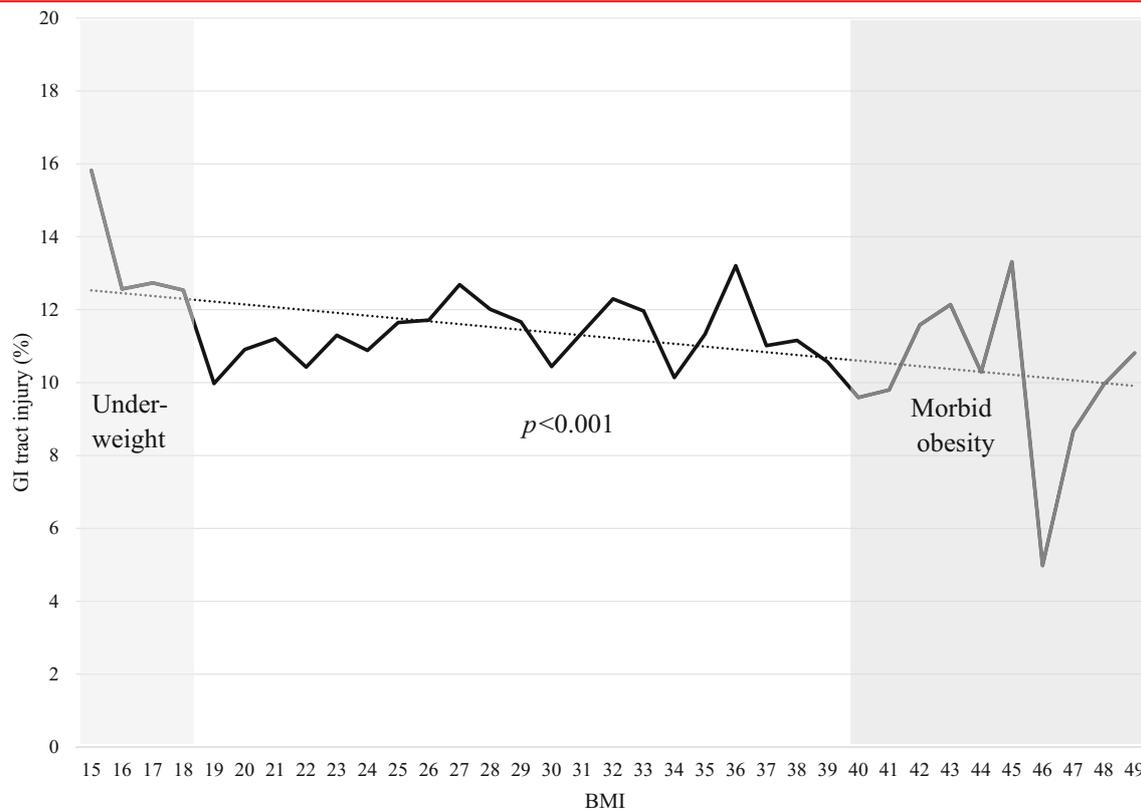


Fig. 1 Relationship between GI tract injury and BMI in all BAT patients

Table 1 shows comparisons between the BAT patients with and without GI tract injuries. In patients with GI tract injuries, 3.7% (427/11467) of the patients were morbidly obese as compared to patients without GI tract injuries (4.2%, 3747/88992) ($p = 0.015$). BAT patients with GI tract injury also had a significantly higher proportion of underweight patients (5.9% vs. 5.0%, $p < 0.001$). The risk of GI tract injury decreased 11.6% independently in morbidly obese patients and increased 15.7% in underweight patients (Table 2).

Among patients with GI tract injuries ($N = 11,467$), there was an inverse relationship between BMI and the need for abdominal operation (Fig. 2). Compared with patients who did not undergo abdominal operations, patients who underwent abdominal operations ($N = 8752$) had significantly lower BMIs (26.9 vs. 27.4, $p = 0.032$) and had a lower proportion of morbidly obese patients (3.2% vs. 5.3%, $p < 0.001$) (Table 3). The risk of abdominal operation in patients with GI tract injury decreased 32.6% independently in morbidly obese patients compared to normal BMI (Table 4).

Injury severity score (ISS) along with weight was significantly associated with GI tract injury. In the current study, there were 5131 (5.1%) underweight patients and

4174 (4.2%) morbidly obese. While morbidly obese patients were significantly older and female, these two extreme groups had a similar ISS. Compared with underweight patients, morbidly obese patients had a significantly lower GI tract injury rate (6.0% vs. 13.3%, $p < 0.001$) and associated abdominal operation rate (65.2% vs. 73.3%, $p < 0.001$) (Table 5).

Discussion

The results of the current study showed a protective mechanism of obesity in BAT. Compared with underweight patients who lack such protection, morbidly obese patients had a lower rate of GI tract injury and a lower need for operation.

Morbid obesity is usually associated with abdominal and visceral obesity. Accumulation of abdominal fat, particularly in the visceral compartment, may confer the majority of obesity-associated health risks. Abdominal obesity has been linked to several metabolic and vascular diseases [13–15]. Higher BMI is also associated with increased technical difficulties and postoperative morbidity for patients who need surgical treatment [16, 17]. Obese

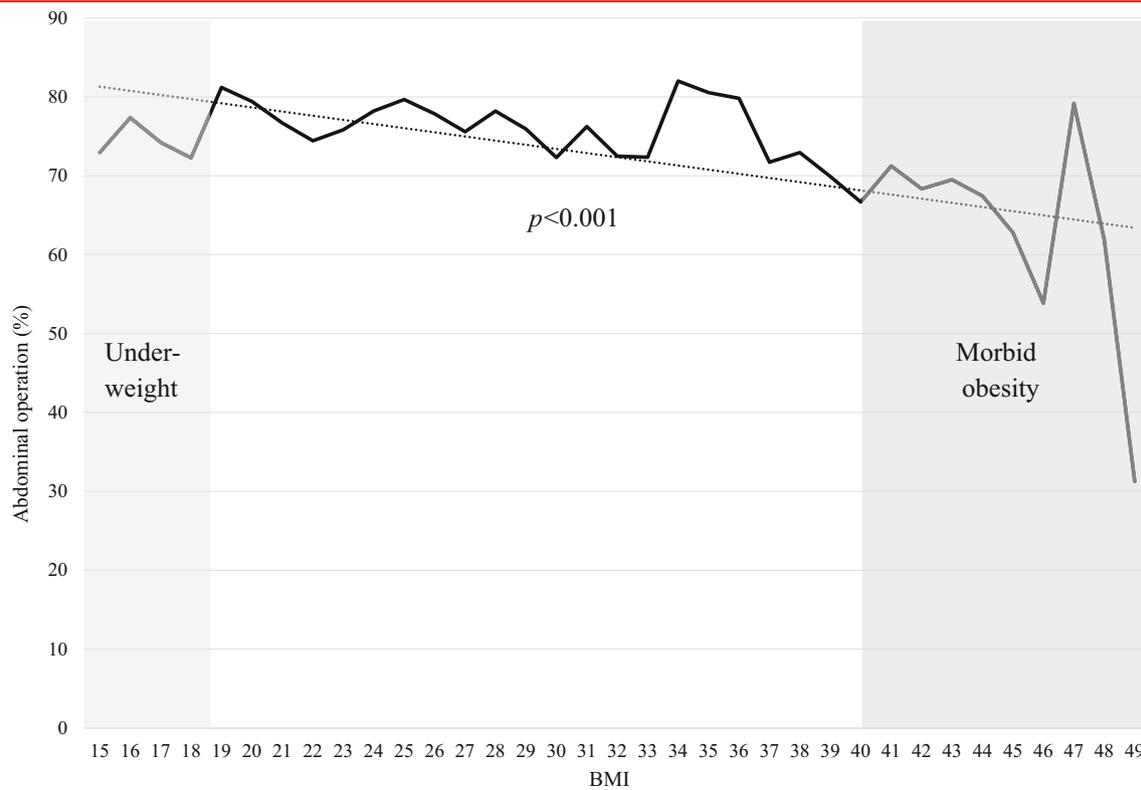


Fig. 2 Relationship between abdominal operation and BMI in GI tract injury patients

Table 1 Comparisons between patients with and without GI tract injuries in BAT ($N = 100,459$)

	With GI tract injuries ($N = 11,467$)	Without GI tract injuries ($N = 88,992$)	p value
Age	37.7 ± 21.3	38.8 ± 24.5	0.664 ^a
Male (N, %)	7230 (63.1%)	55,836 (62.7%)	0.527 ^b
ISS (median, interquartile range)	17, 9–29	17, 9–25	< 0.001 ^a
BMI	27.0 ± 6.2	27.1 ± 6.3	1.000 ^b
Obesity (N, %)	3127 (27.3%)	24,885 (28.0%)	0.121 ^a
Underweight (N, %)	682 (5.9%)	4449 (5.0%)	< 0.001 ^b
Morbid obesity (N, %)	427 (3.7%)	3747 (4.2%)	0.015 ^a

^aStudent T test, ^bChi-square test

Table 2 Risk factors and associated odds ratio of GI tract injury in BAT patients

Variables	Odds ratio	p value [*]	95% CI.
ISS	1.012	< 0.001	1.010–1.013
Morbid obesity	0.887	0.021	0.801–0.982
Underweight	1.235	< 0.001	1.136–1.346

*Logistic regression

trauma patients who may need both intensive medical care and surgical treatment may have poorer outcomes than non-obese patients [18–20].

Visceral fat is packed between the internal abdominal organs and central abdominal fat encircles the torso. In addition, the greater omentum covers the small and large intestines. Internal organs might be protected by a thick omentum and subcutaneous abdominal fat in obese patients. Given the previously reported medical and surgical morbidities associated with obesity, it is unclear whether obesity in trauma is beneficial in the final analysis.

Table 3 Patients with GI tract injury with and without abdominal operations ($N = 11,467$)

	Abdominal operation (+) ($N = 8752$)	Abdominal operation (–) ($N = 2715$)	p value
Age	37.6 ± 20.8	38.1 ± 22.9	0.144 ^a
Male (N, %)	5443 (62.2%)	1787 (65.8%)	< 0.001 ^b
ISS (median, interquartile range)	18, 10–29	14, 6–24	< 0.001 ^a
BMI	26.9 ± 6.0	27.4 ± 6.6	0.032 ^a
Obesity (N, %)	2327 (26.6%)	800 (28.0%)	0.003 ^a
Underweight (N, %)	500 (5.7%)	182 (6.7%)	0.063 ^a
Morbid obesity (N, %)	284 (3.2%)	143 (5.3%)	< 0.001 ^a

^aStudent T test, ^bChi-square test

Table 4 Risk factors and associated odds ratio of abdominal operation in GI tract injury patients

Variables	Odds ratio	p value [*]	95% CI.
Male	0.851	0.001	0.776–0.932
ISS	1.023	< 0.001	1.019–1.027
BMI	–	0.208	–
Obesity	–	0.246	–
Morbid obesity	0.674	0.002	0.524–0.867

*Logistic regression

We sought to study whether obesity is beneficial in blunt abdominal trauma patients who may or may not require an operation.

The results of the current NTDB analysis show that there is an inverse relationship between GI tract injury and BMI in BAT patients (Fig. 1). Patients with GI tract injuries had a significantly lower proportion of morbidly obese patients (3.7% vs. 4.2%, $p = 0.015$). This group also had a higher proportion of underweight patients (5.9% vs. 5.0%, $p < 0.001$) (Table 1). After controlling for covariates, multivariate logistic regression analysis showed morbid obesity was an independent protective factor for GI tract injury in BAT patients (odds ratio = 0.887, $p = 0.021$). Conversely, possibly due to the lack of protection of abdominal and visceral fat, a very low BMI was an

independent risk factor of GI tract injury in BAT patients (odds ratio = 1.235, $p < 0.001$). When adjusted for injury severity and demographics, the protective effect of BMI on BAT persisted. Though most literature addresses the disadvantages of morbid obesity in medical and surgical conditions, it is interesting that morbid obesity eventually serves as a protective mechanism for patients in trauma.

The effect of morbid obesity on patients who require operative treatment for GI tract injury raises another interesting issue. BAT-related GI tract injury ranges from minor bruising of the intestine to small perforation, and even to complete devascularization or transection. For high-grade GI tract injuries, such as perforation or transection, surgical repair is usually needed. However, patients with minor contusions of the GI tract or hematoma can be treated non-operatively [21–23]. In the current study, 24.7% of GI tract injury patients were treated non-operatively. Patients who received abdominal operations had significantly lower BMI (26.9 vs. 27.4, $p = 0.032$) and a lower proportion of morbid obesity than patients who did not receive operation (3.2% vs. 5.3%, $p < 0.001$). Morbid obesity independently predicts successful non-operative management in GI tract injury (odds ratio = 0.674, $p = 0.002$).

Contrasted with subcutaneous fat which encircles the torso, visceral fat is inside the peritoneal cavity and packed in between internal organs and the torso. Fat which

Table 5 Comparisons between the patients with underweight and morbid obesity in the BAT patients

	Underweight ($N = 5131$)	Morbid obesity ($N = 4174$)	p value
Age	19.1 ± 24.3	44.6 ± 17.6	< 0.001 ^a
Male (N, %)	2799 (54.6%)	2172 (52.0%)	0.004 ^b
ISS (median, interquartile range)	13, 9–22	17, 10–26	0.076 ^a
GI tract injury (N, %)	682 (13.3%)	250 (6.0%)	< 0.001 ^a
Requirement of abdominal operation in GI tract injury patients (N, %)	500/682 (73.3%)	163/250 (65.2%)	0.019 ^a

^aStudent T test, ^bChi-square test

surrounds the GI tract might protect the GI tract and reduce injury severity.

High BMI is a major public health problem and is associated with medical problems, including diabetes, coronary artery disease, hypertension, hyperlipidemia and certain types of cancer [4, 5, 24]. However, a low BMI does not always lend itself to better outcomes. The World Health Organization defines a BMI of less than 18.5 as underweight, and this may point to malnutrition, or other health problems [25]. Severely underweight individuals may have a poor physiologic reserve and a weak immune system, leaving them open to infection [26–28]. In addition to lack of mechanical protection by adipose tissue, underweight patients may also lack physiologic protection provided by fat stores. Compared with morbidly obese patients, underweight patients had a significantly higher probability of GI tract injury (13.3% vs. 6.0%, $p < 0.001$) and the associated need for surgery (73.3% vs. 65.2%, $p = 0.019$).

The National Trauma Data Bank with a BAT sample size of 100,459 patients was evaluated in the current study. The study is limited due to its retrospective nature and missing data. It is also possible that some patients may have been operated upon for solid organ injury and GI tract injury was incidentally discovered and repaired. In addition, BMI does not exactly describe fat distribution. Waist circumference is an alternative marker of abdominal fat mass because of its correlation with abdominal fat mass (subcutaneous and intra-abdominal) [29, 30]. Further studies with prospective design and long-term follow-up are needed. These studies need inclusion of the waist circumference and adipose distributions of patients in their databases.

Conclusion

Obesity is protective in BAT. This translates into lower rates of GI tract injury and operation in morbidly obese patients. In contrast, underweight patients appear to suffer a higher rate of GI tract injury and associated GI operations.

Author contribution Bokhari, Fu and Bajani contributed to study conception and design. Fu contributed to acquisition of data. Bokhari, Fu, Welsh, Bajani, Starr, Messer, Dennis, Kaminsky, Mis, Schlanser and Poulakidas analyzed and interpreted the data. Bokhari, Fu and Bajani drafted the manuscript. Bokhari, Fu and Bajani critically revised the manuscript.

Conflict of interest The authors have no commercial associations or sources of support that might pose a conflict of interest.

References

- World Health Organization (2000) Obesity: preventing and managing the global epidemic. Report of a WHO consultation. World Health Organ Tech Rep Ser 894:1–253
- Berghofer A, Pischon T, Reinhold T et al (2008) Obesity prevalence from a European perspective: a systematic review. *BMC Public Health* 8:200
- Calle EE, Thun MJ, Petrelli JM et al (1999) Body-mass index and mortality in a prospective cohort of U.S. adults. *N Engl J Med* 341:1097
- Haslam DW, James WP (2005) Obesity. *Lancet* 366:209–1197
- Schwimmer JB, Burwinkle TM, Varni JW (2003) Health-related quality of life of severely obese children and adolescents. *JAMA* 289:1813–1819
- Bège T, Lelong B, Francon D et al (2009) Impact of obesity on short-term results of laparoscopic rectal cancer resection. *Surg Endosc* 23:4–1460
- Chen CL, Shore AD, Johns R et al (2011) The impact of obesity on breast surgery complications. *Plast Reconstr Surg* 128:395e–402e
- Drenick EJ, Bale GS, Seltzer F et al (1980) Excessive mortality and causes of death in morbidly obese men. *JAMA* 243:443–445
- Krishna SG, Hinton A, Oza V et al (2015) Morbid obesity is associated with adverse clinical outcomes in acute pancreatitis: a propensity-matched study. *Am J Gastroenterol* 110:19–1608
- Kalantar-Zadeh K, Block G, Horwich T, Fonarow GC (2004) Reverse epidemiology of conventional cardiovascular risk factors in patients with chronic heart failure. *J Am Coll Cardiol* 43:44–1439
- Niedziela J, Hudzik B, Niedziela N et al (2014) The obesity paradox in acute coronary syndrome: a meta-analysis. *Eur J Epidemiol* 29:12–801
- Romero-Corral A, Montori VM, Somers VK et al (2006) Association of bodyweight with total mortality and with cardiovascular events in coronary artery disease: a systematic review of cohort studies. *Lancet* 368:78–666
- Yusuf S, Hawken S, Ounpuu S et al (2004) Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. *Lancet* 364:52–937
- Razay G, Vreugdenhil A, Wilcock G (2006) Obesity, abdominal obesity and Alzheimer disease. *Dement Geriatr Cogn Disord* 22:6–173
- Cameron AJ, Zimmet PZ (2008) Expanding evidence for the multiple dangers of epidemic abdominal obesity. *Circulation* 117:6–1624
- Gendall KA, Raniga S, Kennedy R, Frizelle FA (2007) The impact of obesity on outcome after major colorectal surgery. *Dis Colon Rectum* 50:37–2223
- Scheidebach H, Benedix F, Hügel O et al (2008) Laparoscopic approach to colorectal procedures in the obese patient: risk factor or benefit? *Obes Surg* 18:66–70
- Glance LG, Li Y, Osler TM et al (2014) Impact of obesity on mortality and complications in trauma patients. *Ann Surg* 259:81–576
- Dhungle V, Liao J, Raut H et al (2015) Obesity delays functional recovery in trauma patients. *J Surg Res* 193:20–415
- Ditillo M, Pandit V, Rhee P et al (2014) Morbid obesity predisposes trauma patients to worse outcomes: a national trauma data bank analysis. *J Trauma Acute Care Surg* 76:9–176
- Watts DD, Fakhry SM (2003) East multi-institutional hollow viscus injury research group incidence of hollow viscus injury in blunt trauma: an analysis from 275,557 trauma admissions from the east multi-institutional trial. *J Trauma* 54:289–294

22. Hughes TM, Elton C, Hitos K et al (2002) Intra-abdominal gastrointestinal tract injuries following blunt trauma: the experience of an Australian trauma centre. *Injury* 33:26–617
23. Bège T, Chaumoître K, Léone M et al (2014) Blunt bowel and mesenteric injuries detected on CT scan: who is really eligible for surgery? *Eur J Trauma Emerg Surg* 40:75–81
24. Vucenik I, Stains JP (2012) Obesity and cancer risk: evidence, mechanisms, and recommendations. *Ann N Y Acad Sci* 1271:37–43
25. World Health Organization (1995) Physical status: the use and interpretation of anthropometry. World Health Organization; 1995 WHO Technical Report Series. Geneva
26. Carbone F, La Rocca C, De Candia P et al (2016) Metabolic control of immune tolerance in health and autoimmunity. *Semin Immunol* 28:491–504
27. Harpsøe MC, Nielsen NM, Friis-Møller N et al (2016) Body mass index and risk of infections among women in the Danish National Birth Cohort. *Am J Epidemiol* 183:17–1008
28. Phung DT, Wang Z, Rutherford S et al (2013) Body mass index and risk of pneumonia: a systematic review and meta-analysis. *Obes Rev* 14:839–857
29. Grundy SM, Neeland IJ, Turer AT, Vega GL (2013) Waist circumference as measure of abdominal fat compartments. *J Obes* 2013:454285
30. Berentzen TL, Ängquist L, Kotronen A et al (2012) Waist circumference adjusted for body mass index and intra-abdominal fat mass. *PLoS ONE* 7:e32213