

TECHNICAL NOTE**PATHOLOGY/BIOLOGY**

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The Association Between Body Mass Index and Pulmonary Thromboembolism in an Autopsy Population

ABSTRACT: To evaluate the association between obesity and pulmonary thromboembolism (PTE) in a forensic context, 160 autopsy cases of fatal PTE were compared with age- and gender-matched controls. The mean age of cases was 66 years (range 26–98 years; M/F 74:86). The mean body mass index (BMI) of cases with PTE was 30.88 (range 14.95–79.51), which was significantly higher than in the controls (mean BMI = 25.33; range 12.49–61.84) ($p < 0.0001$). Comparing the group with PTE with controls showed that five (3.1%) compared to 20 (12.5%) were underweight, 39 (24.4%) compared to 67 (41.88%) were of normal weight, 49 (30.63%) compared to 43 (26.88%) were overweight, 43 (26.88%) compared to 24 (15%) were obese, and 24 (15.0%) compared to six (3.75%) were morbidly obese. In each category of above-normal BMIs, there were significantly greater numbers in the groups with PTE: overweight ($p < 0.01$), obese ($p < 0.001$), and morbidly obese ($p < 0.0001$).

KEYWORDS: forensic science, obesity, pulmonary thromboembolism, DVT, BMI, risk factor, thrombophilia, thrombus, autopsy

Obesity has become a major health concern in Western countries in recent years reaching “epidemic” proportions (1,2). A recent study of adult body weights from 199 countries between 1980 and 2008 showed an increase in the mean body mass index (BMI) of 0.4 kg/m²/decade, with a proportionately greater increase in countries such as the United States, Australia, and New Zealand (3). The serious medical, financial, and social consequences are well recognized and are mainly due to the increased risk of cardiovascular and renal disease, arthritis, type 2 diabetes mellitus, and certain malignancies (2,4). As the pathological effects of obesity include alterations in inflammatory responses, the coagulation cascade and overall thrombotic potential (5–7), the role of obesity and raised BMI as a risk factor for venous thromboembolism is increasingly being recognized (8–12).

However, the association of obesity and pulmonary thromboembolism (PTE) has not been extensively studied in a forensic setting (13), and so the following study was undertaken to determine whether obesity was significantly associated with fatal PTE in an autopsy population.

Materials and Methods

One hundred and sixty autopsy cases where sudden and unexpected death had been attributed to PTE were randomly selected from the case files at Forensic Science SA from January 2004 to

December 2008. One hundred and sixty age- and gender-matched controls were then selected from the case files over the same period. All of the cases had full autopsies with complete coronial and police investigations. Case files were reviewed, and the gender, age, height, and weight were recorded. BMI was calculated for each case (as the weight in kilograms divided by the square of the height in meters) and classified as underweight, normal, overweight, obese, or morbidly obese according to the World Health Organization definitions: BMI < 18.5 underweight; 18.5–24.99 normal; 25–29.99 overweight (preobese); 30–39.99 obese; and ≥ 40 morbidly obese (obesity class III) (http://apps.who.int/bmi/index.jsp?introPage=intro_3.html, accessed March 20, 2011). Forensic Science SA is the South Australian state forensic facility where medico-legal autopsies are performed. The population served is approximately 1.6 million. Statistical analyses were performed using the Student’s *t*-tests and Pearson’s chi-square tests.

Results

The mean age of the 160 cases with fatal PTE and the 160 controls was 66 years (range 26–98 years), with a male-to-female ratio of 74:86. The mean BMI of the cases with PTE was 30.88 (range 14.95–79.51), which was significantly higher than in the controls where the mean BMI was 25.33 (range 12.49–61.84) ($p < 0.0001$).

In the group with PTE, five (3.1%) were underweight, 39 (24.4%) had a BMI in the normal range, 49 (30.63%) were overweight, 43 (26.88%) were obese, and 24 (15.0%) were morbidly obese. In the age- and gender-matched control group, 20 (12.5%) were underweight, 67 (41.88%) had a BMI in the normal range, 43 (26.88%) were overweight, 24 (15%) were obese, and six (3.75%) were morbidly obese (Table 1; Fig. 1). In each category of above-normal BMIs, there were significantly greater numbers in the

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TABLE 1—Numbers of cases of fatal pulmonary thromboembolism (PTE) in different body mass index (BMI) groups compared with controls.

	Individuals with BMI <30 (overweight, normal, and underweight)	Individuals with BMI 30–39.99 (obese)	Individuals with BMI ≥40 (morbidly obese)
Fatal PTE	93 (58%)	43 (27%)	24 (15%)
Control	130 (81%)	24 (15%)	6 (4%)

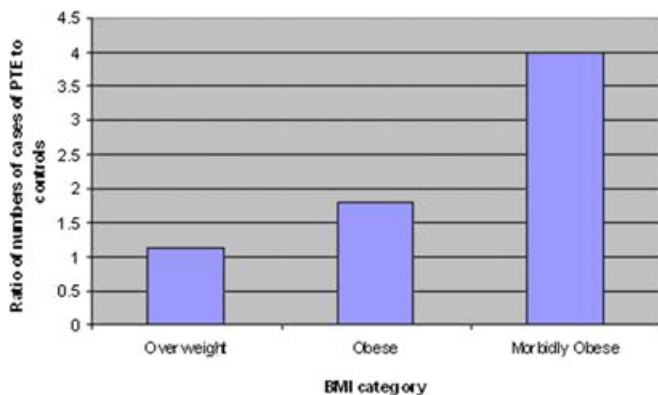


FIG. 1—Ratio of the numbers of cases of individual who were overweight, obese, or morbidly obese in the group with pulmonary thromboembolism (PTE) compared with controls.

groups with PTE: overweight ($p < 0.01$), obese ($p < 0.001$), and morbidly obese ($p < 0.0001$).

Discussion

The mechanism by which obesity is believed to predispose to deep venous thrombosis and PTE is multifactorial, involving reduced mobility, decreased venous return, and a probable hypercoagulable state (6,14). The latter is thought to be mediated by raised levels of fibrinogen, plasminogen activator inhibitor, factor VII, and factor VIII (5,7).

Lucena et al. in an autopsy study found that 75% of fatal PTE cases were overweight or obese, with a mean BMI of 31.5 (15), a feature confirmed in the current study. Given that the prevalence of obesity in the United States is expected to rise to 49.9% by 2030 and to 33.9% in Australia by 2025 (16,17), this would suggest that the number of cases of fatal and nonfatal PTE should also be expected to increase. As PTE is a well-known cause of sudden and unexpected death, it is therefore likely that forensic facilities will be seeing more of these cases in the future.

Unfortunately, performing autopsies on obese and morbidly obese individuals poses many challenges for current mortuaries, which are generally designed to accommodate bodies of normal size. Difficulties arise with the storing of obese bodies in conventional refrigeration bays and in transferring bodies on standard trolleys (18). Performing autopsies on obese individuals is technically harder than in the thin individuals and may impede diagnostic evaluation. For example, obtaining adequate exposure to enable calf dissection of deep tissues for deep venous thrombosis to be performed may be very difficult in the massively obese. Large bodies also putrefy more rapidly than those with a normal BMI, and this may complicate evaluation of possible thromboembolism (19).

With the number of obese individuals assessed forensically continuing to increase, it may become necessary, therefore, to alter existing facilities in mortuaries and to adapt current autopsy techniques to deal satisfactorily with these issues. As the diagnosis of PTE may be readily made clinically using computed tomographic (CT) scanning (20,21), there may be a cogent argument for postmortem radiological screening of obese bodies when a cause of death is not apparent. This may minimize the technical, logistical, and safety issues posed by handling bodies of excessive weight and may spare families the burden of a postmortem investigation. However, not only will all forensic mortuaries need to install CT scanners, but they will have to be specially constructed to enable the handling of bodies with BMIs as high as 80.

Although the link between obesity and PTE has been demonstrated in clinical and forensic settings previously (9,15), the current study has shown that this link becomes increasingly significant with increasing BMI, ranging from $p < 0.01$ in the overweight to $p < 0.001$ in the obese, and finally $p < 0.0001$ in the morbidly obese.

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