

# Penetrating thoracoabdominal injuries in Quebec: implications for surgical training and maintenance of competence

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**Background:** The frequency of penetrating trauma is low in Canada. Current recommendations for the care of patients with penetrating injuries originate from inner city trauma centres with a high volume of such injuries and may not apply to Canada. The purpose of this study was to review the incidence and treatment of penetrating thoracoabdominal injuries in the 4 tertiary trauma centres in Quebec. **Methods:** We identified all patients with penetrating thoracic or abdominal injuries who were taken to any of the 4 tertiary trauma centres in the province of Quebec between Apr. 1, 1998, and Mar. 31, 2001. Patients who were dead on arrival were excluded. Only patients with an Abbreviated Injury Scale of 2 or greater for the thoracic or abdominal regions were included. **Results:** In total, 245 patients meeting our inclusion criteria were identified. Of these 223 (91%) were male. The mean (and standard deviation) age was 33.8 (13.2) years; range 15–90 years. The median Injury Severity Score was 10 (range 4–75). Overall in-hospital mortality was 6.9%. There were 203 patients (82.8%) with thoracic injuries and 192 patients (78.4%) with abdominal injuries. Fifty (20.4%) of these patients had injuries to both regions. A thoracotomy was carried out in 48 (31.4%) of 153 patients who had injuries to the thorax, and the abdomen was explored in 133 (93.7%) of the 142 patients with abdominal injuries. The incidence of these injuries in the study period varied from 3 to 49 cases per centre. **Conclusions:** The annual incidence of penetrating thoracoabdominal injuries is extremely low in all 4 of Quebec's tertiary trauma centres, and the number of thoracoabdominal procedures is even lower. Such a low exposure may jeopardize education and clinical competence. We need to rethink our educational strategies both for residents and for continuing medical education. New approaches to training and maintenance of competence must be developed.

**Contexte :** La fréquence des traumatismes perforants est faible au Canada. Les recommandations en vigueur sur le traitement des patients victimes de traumatismes perforants proviennent de centres de traumatologie de centres-villes qui traitent un volume élevé de ces traumatismes et il se peut qu'elles ne s'appliquent pas à l'ensemble du pays. Cette étude visait à analyser l'incidence et le traitement des traumatismes thoracoabdominaux perforants dans quatre centres tertiaires de traumatologie du Québec. **Méthodes :** Nous avons identifié tous les patients victimes de traumatismes thoraciques ou abdominaux perforants qui ont été transportés à l'un des quatre centres tertiaires de traumatologie du Québec entre le 1er avril 1998 et le 31 mars 2001. On a exclu les patients déclarés morts à l'arrivée. On a inclus seulement ceux qui ont obtenu un résultat de 2 ou plus sur la liste type des blessures dans les régions thoracique ou abdominale. **Résultats :** Au total, on a identifié 245 patients répondant à nos critères d'inclusion, dont 223 (91 %) étaient des hommes. Les patients avaient en moyenne (et écart type) 33,8 (13,2) ans et leur âge variait de 15 à 90 ans. Le résultat médian selon la liste type des blessures s'est établi à 10 (plage de 4 à 75). Le taux global de mortalité à l'hôpital a atteint 6,9 %. On a compté 203 patients (82,8 %) victimes de traumatismes au thorax et 192 (78,4 %) victimes de traumatismes à l'abdomen. Cinquante (20,4 %) de ces patients étaient atteints dans les deux régions. On a procédé à une thoracotomie chez 48 patients sur 153 (31,4 %) et on a exploré l'abdomen de 133 patients sur 142

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(93,7 %) atteints à l'abdomen. L'incidence de ces traumatismes au cours de la période d'étude a varié de 3 à 49 cas par centre. **Conclusions :** L'incidence annuelle des traumatismes thoracoabdominaux perforants est extrêmement faible dans les quatre centres tertiaires de traumatologie du Québec et le nombre d'interventions thoracoabdominales est encore plus bas. Une exposition aussi faible peut menacer la formation et la compétence cliniques. Il faut repenser nos stratégies de formation dans le cas à la fois des résidents et de l'éducation médicale continue. Il faut élaborer de nouvelles stratégies de formation et de maintien des compétences.

The frequency of penetrating trauma is low in Canadian centres.<sup>1,2</sup> Several American studies have reported a link between high trauma volume and improved outcome.<sup>3-5</sup> An annual volume of 35 seriously injured patients per surgeon is associated with decreased mortality.<sup>3</sup> For this reason, the American College of Surgeons established criteria for level I trauma centres.<sup>6</sup> The Residency Review Committee for Surgery requires a minimum of 16 operations on trauma patients per resident.<sup>7</sup> Yet many centres cannot attain these minimum volume requirements.<sup>8-10</sup>

A striking decrease of 60% was reported in the number of thoracotomies and laparotomies performed in the United States over the last decade.<sup>11,12</sup> Penetrating trauma rarely exceeds 10% of total trauma volume in Canadian trauma centres,<sup>1</sup> so experience is difficult to acquire and maintain.<sup>1</sup> In the United Kingdom, the reported median number of annual laparotomies performed by surgeons is 2 for blunt trauma and 1 for penetrating injuries.<sup>13</sup> This problem is not unique to Canada as in the US a low 6.4 cases per resident over 3 years was reported at 2 (level I and level II) trauma centres.<sup>14</sup>

Trauma has increasingly become a nonoperative discipline.<sup>12,15,16</sup> Major concerns have been raised regarding the link between volume and quality

of residents' surgical training in trauma.<sup>12,14,17</sup> We suspect that the problem is even worse in Quebec. The purpose of this study was to review the incidence and treatment of penetrating thoracoabdominal injuries in Quebec tertiary trauma centres over a 4-year period.

**Methods**

The use of the Quebec Trauma Registry, a standardized database, is mandatory for all trauma centres in the province. It includes all trauma patients meeting any of 4 criteria: hospital stay longer than 2 days, inter-hospital transfer, admission to an intensive care unit or death either in the emergency department or after hospitalization. The registry was used to identify all patients with penetrating thoracic or abdominal injuries, or both, from Apr. 1, 1998, to Mar. 31, 2002. The 4 tertiary trauma centres in the province of Quebec are: Hôpital Enfant-Jésus in Québec; Hôpital Charles-LeMoyne in Montérégie; and Montreal General Hospital and Hôpital Sacré-Coeur, both in Montréal. All patients admitted to any of the 4 tertiary trauma centres were included when they met entry criteria. Patients with no vital signs on arrival at the emergency department were excluded as were patients without an

Abbreviated Injury Scale (AIS) score of 2 or greater for either the thoracic or abdominal regions.

Patient characteristics — admission centre, age, sex, mechanism of injury, AIS for the thoracic and abdominal regions,<sup>18</sup> Injury Severity Score (ISS),<sup>19</sup> Revised Trauma Score (RTS),<sup>20</sup> Glasgow Coma Scale (GCS) score, Penetrating Abdominal Trauma Index (PATI),<sup>21</sup> injuries, surgical interventions, length of hospital stay and status at discharge — were obtained from the trauma registry. Results are given as means (and standard deviation) or as means (and ranges).

**Results**

Over the 4-year study period, 17 134 patients were included in the trauma registries for all 4 centres. As shown in Table 1, only 4% of the patients had sustained a penetrating wound to any body region, half of which were to the abdomen or thorax. After excluding patients without vital signs in the emergency department and those whose thoracic or abdominal AIS score was less than 2, only 245 patients (1.4% of all trauma registry entries) remained. The number of patients by centre was, respectively, 21, 32, 134 and 58 (Table 2).

Among the 245 patients meeting the inclusion criteria, there were 223 males (91.0%) and 22 females

**Table 1**  
Distribution of patients in the Quebec Trauma Registry

Patient type	Year; no. (%) of patients				Total, no. (%) of patients
	1998-99	1999-2000	2000-01	2001-02	
In the trauma registry	4 672 (100)	4 450 (100)	4 332 (100)	3 680 (100)	17 134 (100)
Penetrating trauma	244 (5.2)	177 (4.0)	147 (3.4)	136 (3.7)	704 (4.1)
Penetrating trauma to thorax or abdomen	125 (2.7)	79 (1.8)	83 (1.9)	75 (2.0)	362 (2.1)
Meeting our inclusion criteria	86 (1.8)	44 (1.0)	65 (1.5)	50 (1.4)	245 (1.4)

(9.0%). Mean age was 33.8 (SD 13.2; range 15–90) years. The mechanism of injury was a stab wound in 62 cases (25.3%), a gunshot wound in 160 cases (65.3%) and other penetrating objects in 23 cases (9.4%).

The median ISS was 10 (range 4–75). ISS was 4–8 in 22 cases (9.0%); 9–15 in 155 cases (63.3%); 16–24 in 39 cases (15.9%); 25–40 in 26 cases (10.6%); 41–75 in 3 cases (1.2%). The maximum RTS was obtained in 206 patients (84.1%). The GCS score was 13–15 in 229 patients (93.5%). Patients had normal arterial blood pressure in 230 cases (93.9%). Patients were eupneic in 229 cases (93.5%).

Thoracic and abdominal injuries with an AIS score of 2 or greater were present in 203 patients (82.8%) and 192 patients (78.4%) respectively. Fifty patients (20.4%) had both thoracic and abdominal injuries. In patients with abdominal injuries, the median PATI was 12 (range 4–57). Excluding thoracic drains, a surgical procedure was carried out in 150 (61.2%) of the 245 patients. Forty-eight patients with thoracic injuries underwent surgery (19.6%). This represents 31.4% of the 153 patients who had injuries to the thoracic region. For patients with abdominal injuries, a surgical intervention was done in 133 (54.3%) of the 245 patients. This represents 93.7% of the 142 patients who had abdominal injuries. Five patients underwent laparoscopy for diagnostic purposes. Four of these patients did not undergo laparotomy. In the remaining 129 patients, the laparotomy was nontherapeutic in 26 (20.2%).

For the thoracic region, the most frequent injuries were hemopneumothorax, lung injuries and diaphragmatic rupture. For the abdominal region, the most frequent lesions were liver, small-bowel and colonic injuries (Table 3, Table 4).

Seventeen (6.9%) of the 245 patients died; 11 of these had thoracic injuries and 14 had abdominal injuries. Both regions were injured in 8 patients who died. Causes of death were hemorrhagic shock (8 cases), multisystem organ failure and sepsis (3 cases), brain death from cranial injury (3 cases), cardiac injury (2 cases) and respiratory insufficiency (1 case). Among the survivors, the mean (and SD) hospital stay was 11.4 (13.8) days. The median hospital stay was 8 (range 1–142) days.

### Discussion

Several studies claim that high-volume trauma centres achieve better patient outcomes.<sup>3,22,23</sup> This was not confirmed by a recent analysis of the

National Trauma Databank.<sup>24</sup> However, with low penetrating trauma rates, volume requirements are more difficult to attain,<sup>9,10,14,17</sup> thus decreasing experience and opportunities to maintain competence in trauma management.<sup>1</sup> Because of the evolution of general surgery toward a principally “nonoperative field” in traumatology and consequently the difficulty in accruing enough operative cases,<sup>12,15,16,25</sup> the Residency Review Committee for Surgery of the American College of Surgeons has approved the addition of “major organ trauma, no operation required” to the trauma defined category.<sup>26</sup> From a minimum of 16 operative cases, an increase to a minimum of 30 such patients was approved. However, these minimum requirements are further divided into 10 operative cases and 20 nonoperative cases. This situation illustrates future trends in trauma.

The present study was done to evaluate the exposure of general surgeons and residents to penetrating

**Table 2**

**Annual distribution of patients by centre**

Centre no.	1998–99	1999–2000	2000–01	2001–02	Total
1	10	3	3	5	21
2	6	8	10	8	32
3	49	26	26	33	134
4	21	7	26	4	58
Total	86	44	65	50	245

**Table 3**

**Distribution of 153 thoracic injuries**

Injury	No. (%)
Hemopneumothorax	126 (82.3)
Lung	39 (25.5)
Diaphragm	28 (18.3)
Ribs	23 (15.0)
Heart	14 ( 9.2)
Hemopneumomediastinum	8 ( 5.2)
Large vessels	4 ( 2.6)
Esophagus	3 ( 2.0)
Trachea and bronchus	3 ( 2.0)
Sternum	1 ( 0.6)

**Table 4**

**Distribution of 142 abdominal injuries**

Injury	No. (%)
Liver	52 (36.6)
Small bowel	34 (23.9)
Colon	33 (23.2)
Large vessels	31 (21.8)
Stomach	24 (16.9)
Kidney	18 (12.7)
Mesentery	15 (10.6)
Omentum	14 ( 9.8)
Pancreas	10 ( 7.0)
Retroperitoneum	10 ( 7.0)
Duodenum	10 ( 7.0)
Spleen	8 ( 5.6)
Rectum	7 ( 4.9)
Bladder	4 ( 2.8)
Gallbladder	4 ( 2.8)
Scrotum and penis	3 ( 2.1)
Anus	2 ( 1.4)
Ureter	1 ( 0.7)
Ovary	1 ( 0.7)
Uterus	1 ( 0.7)
Vagina	1 ( 0.7)

thoracoabdominal injuries in a Canadian province. This study was population-based as all the tertiary trauma centres were included, and the Quebec trauma system involves a “no refusal policy” for the transfer of severe injuries to these centres that is strictly monitored and enforced. The period of study was chosen because the data were complete for the 4 trauma centres in the provincial trauma registry. The Quebec registry excludes patients with a hospital stay of less than 3 days, so this study may underestimate the number of patients who were subject to observation. Although this information could be relevant, the goal of the study was to estimate the number of patients for whom the involvement of surgeons was significant. We doubt that the inclusion of patients with thoracoabdominal penetrating injuries hospitalized for only 1 or 2 days would have changed our conclusions.

The volume of surgically treatable penetrating thoracoabdominal trauma in Quebec tertiary trauma centres (the equivalent to level I) is very low. A large variation exists between years and centres; however, the volume never reached the recommended standards.<sup>7-10</sup> The caseload ranged from a low volume 3/yr to a high volume of 49/yr. In the last year of the study, there was a total of only 50 cases among the 4 centres. Even the highest volume centre (49 cases in 1 year) represented an average of only 1 case per week. Only 1 of the 4 centres reached an overall average of more than 1 case per month. In such a setting, many residents would not even see a case of penetrating thoracoabdominal trauma in their last year of training. A reduction in the number of trauma centres could certainly be envisioned. But even then, with approximately 20 finishing residents a year for the entire province of Quebec, the volume would remain substantially lower than that suggested in the literature. Even if a single centre treated them all, the average number of patients treated per resident would remain at less than 3/yr.

The Quebec trauma system was designed according to the American College of Surgeons’ guidelines.<sup>27</sup> The number of tertiary trauma centres was limited to 4 in order to concentrate expertise according to the criterion of 1 tertiary trauma centre per 1.5 million people. However, the low incidence of penetrating trauma in Canada, which is similar to that of most developed countries, implies dissimilarities with our US counterparts and particular constraints with specific educational challenges. Otherwise, our volume of blunt trauma remains comparable to that of other systems.

The incidence of penetrating thoracoabdominal trauma is even more problematic when we consider that only 150 patients underwent surgery in a 4-year period in all 4 tertiary trauma centres. This study addressed only penetrating injuries but, considering the low rate of surgical procedures in contemporary thoracoabdominal trauma,<sup>11,12,14-16,28,29</sup> the exposure of residents to surgery remains extremely low.<sup>1,13,14</sup>

This low exposure rate raises important concerns about surgeons’ and residents’ experience and training. Even after lowering the requirements, these remain impossible to meet in our centres. And far beyond the worries of meeting these requirements is the need to achieve and maintain competence. Even if some authors challenged the concept of better outcome with higher surgical exposure,<sup>3,9</sup> a certain minimum should certainly be met. The 20% rate of nontherapeutic laparotomy seems high, but it compares to reported rates of 12%–17% in high-volume trauma centres.<sup>30-32</sup> It is important to consider that new trends<sup>28,30,32</sup> are difficult to follow with such a low exposure as encountered in this study.

Possible elements of solutions have been suggested,<sup>12</sup> including questioning the distribution of the tertiary trauma centres. Residents could be exposed to emergency surgery to increase their operative experience as suggested;<sup>33,34</sup> this is al-

ready the case in the residency programs in Quebec. However, combining general surgery emergency and trauma still results in a disturbingly low number of overall operative cases.<sup>35</sup> Surgical courses in trauma could be offered to the residents along with cadaver dissections, work in animal laboratories and virtual reality computer laboratories. Elective rotations in high-volume centres could also be offered,<sup>34</sup> even if it represents a logistically more difficult and expensive alternative. Even then, this option still fails to address maintenance of competence among already practising surgeons.

The problem of the very low incidence of penetrating thoracoabdominal injuries treated in tertiary trauma centres reveals serious concerns for both actual and future surgical residency training programs. Other strategies must certainly be addressed and developed in the near future.<sup>34</sup> Clearly, just changing the minimal requirements to lower the levels does not compensate for the problem of low exposure.

This study undoubtedly demonstrates a low incidence of penetrating thoracoabdominal injuries in Quebec tertiary trauma centres and an even lower number of thoracoabdominal procedures for these patients. Such a weak exposure may jeopardize education and clinical competence. We need to rethink our educational strategies for residents and for continuing medical education. New approaches for training and maintenance of competence must be developed.

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## References

1. Simons R, Kasic S, Kirkpatrick A, Vertesi L, Phang T, Appleton L. Relative importance of designation and accreditation of trauma centers during evolution of a regional

- trauma system. *J Trauma* 2002;52:827-34.
2. Buduhan G, McRitchie DI. Missed injuries in patients with multiple trauma. *J Trauma* 2000;49:600-5.
  3. Konvolinka CW, Copes WS, Sacco WJ. Institution and per-surgeon volume versus survival outcome in Pennsylvania's trauma centers. *Am J Surg* 1995;170:333-40.
  4. O'Keefe GE, Jurkovich GJ, Kopass M, Maier RV. Ten-year trend in survival and resource utilization at a level I trauma center. *Ann Surg* 1999;229:409-15.
  5. Peitzman AB, Courcoulas AP, Stinson C, Udekwi AO, Billiar TR, Harbrecht BG. Trauma center maturation: quantification of process and outcome. *Ann Surg* 1999; 230:87-94.
  6. American College of Trauma Surgeons, Committee on Trauma. *Resources for optimal care of the injured patient, 1999*. Chicago (IL): The College; 1998.
  7. Residency Review Committee. *Requirements for graduating general surgical residents*. East Lansing (MI): Michigan State University; 2002.
  8. American College of Surgeons, Committee on Trauma. *Resources for optimal care of the injured patient, 1993*. Chicago: The College; 1993.
  9. Cooper A, Hannan EL, Bessey PQ, Farrell LS, Cayten CG, Mottley L. An examination of the volume-mortality relationship for New York state trauma centers. *J Trauma* 2000;48:16-23.
  10. Nathens AB, Jurkovich GJ, Maier RV, Grossman DC, MacKenzie EJ, Moore M, et al. Relationship between trauma center volume and outcomes. *JAMA* 2001; 7:1164-71.
  11. Scalea TM, Trooskin SZ, Wait RB. Critical care training makes trauma care more attractive as a career. *J Trauma* 1994; 36:548-54.
  12. Engelhardt S, Hoyt D, Coimbra R, Fortlage D, Holbrook T. The 15-year evolution of an urban trauma center: What does the future hold for the trauma surgeons? *J Trauma* 2001;51:633-8.
  13. Brooks A, Butcher W, Walsh M, Lambert A, Browne J, Ryan J. The experience and training in British general surgeons in trauma surgery for the abdomen, thorax and major vessels. *Ann R Coll Surg Engl* 2002;84:409-13.
  14. Bulinski P, Bachulis B, Naylor DF, Kam D, Carey M, Dean R. The changing face of trauma management and its impact on surgical resident training. *J Trauma* 2003; 54:161-3.
  15. Richardson JD, Miller FB. Will future surgeons be interested in trauma care? Results of a resident survey. *J Trauma* 1992; 32:229-35.
  16. Healey MA, Simons RK, Winchell RJ, Gosink BB, Casola G, Steele JT, et al. A prospective evaluation of abdominal ultrasound in blunt trauma: Is it useful? *J Trauma* 1996;40:875-85.
  17. Parsa CJ, Organ CH, Barkan H. Changing pattern of resident operative experience from 1990 to 1997. *Arch Surg* 2000; 135:570-5.
  18. Association for the advancement of automotive medicine. *The Abbreviated Injury Scale 1990 revision*. Des Plaines (IL): The Association; 1990.
  19. Baker SP, O'Neill B, Haddon W Jr, Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma* 1974;14:187-96.
  20. Champion HR, Sacco WJ, Copes WS, Gann DS, Gennarelli TA, Flanagan ME. A revision of the trauma score. *J Trauma* 1989;29:623-9.
  21. Moore EE, Dunn EL, Moore JB, Thompson JS. Penetrating abdominal trauma index. *J Trauma* 1981;21:439-45.
  22. Smith RF, Frateschi L, Sloan EP, Campbell L, Krieg R, Edwards LC, et al. The impact of volume on outcome in seriously injured trauma patients: two years' experience of the Chicago trauma system. *J Trauma* 1990;30:1066-76.
  23. Tepas JJ, Patel JC, DiScala C, Wears RL, Veldenz HC. Relationship of trauma patient volume to outcome: Can a relationship be defined? *J Trauma* 1998;44:827-31.
  24. Glance LG, Osler TM, Dick A, Mukamel D. The relation between trauma center outcome and volume in the National Trauma Databank. *J Trauma* 2004;56:682-90.
  25. Hoyt DB. Rock on — staying focused on our way to greatness. *J Trauma* 2004; 56:1-6.
  26. Residency Review Committee for Surgery. *Newsletter* Chicago (IL); Spring 2003.
  27. Mitchell FL, Thal ER, Wolferth CC. American College of Surgeons trauma consultation program. *Arch Surg* 1995; 130:576-83.
  28. Lucas CE, Ledgerwood AM. Changing times and the treatment of liver injury. *Am Surg* 2002;66:337-41.
  29. Hawkins ML, Wynn JJ, Schmacht DC, Medeiros RS, Gadacz TR. Nonoperative management of liver and/or splenic injuries: effect on resident surgical experience. *Am Surg* 1998;64:552-7.
  30. Nicholas JM, Parker Rix E, Easley KA, Feliciano DV, Cava RA, Ingram WL, et al. Changing patterns in the management of penetrating abdominal trauma: the more things change, the more they stay the same. *J Trauma* 2003;55:1095-110.
  31. Feliciano DV, Burch JM, Spjut-Patrinely V, Mattox KL, Jordan GL Jr. Abdominal gunshot wounds: an urban trauma center's experience with 300 consecutive patients. *Ann Surg* 1988;208:362-70.
  32. Exadaktylos A, Stettbacher A, Edul S, Nichols A, Bautz P. [Successful management of abdominal stab wounds with clinical evaluation: experiences of a South-African trauma unit with consecutive patients.] *Unfallchirurg* 2003;106:215-9.
  33. Scherer LA, Battistella FD. Trauma and emergency surgery: an evolutionary direction for trauma surgeons. *J Trauma* 2004; 56:7-12.
  34. Richardson JD, Miller FB. Is there an ideal model for training the trauma surgeons in the future? *J Trauma* 2003;54:795-7.
  35. Fakhry SM, Watts DD, Michetti C, Hunt JP. The resident experience on trauma: Declining surgical opportunities and career incentives? Analysis of data from a large multi-institutional study. *J Trauma* 2003;54:1-7.