Original Article

Penetrating Abdominal Trauma Index in Prediction of Postoperative Morbidity and Mortality

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Abstract

Background: Penetrating abdominal trauma is a major health problem worldwide, and in Iraq, it constitutes a main job in the trauma field for general surgeons working across the country. Factors affecting the postoperative complication are well established. Moore found in 1981 that penetrating abdominal trauma score is considered an independent factor for postoperative mortality. **Objective:** The study aimed to evaluate patient outcomes in Al-Yarmuk Teaching Hospital regarding postoperative morbidity and mortality using the penetrating abdominal trauma index (PATI) score. **Patients and Methods:** A cross-sectional study was done for 1 year from April 2022 to April 2023 at Al-Yarmouk Teaching Hospital; 96 patients were admitted to the theater for explorative laparotomy after having the appropriate initial management at the emergency department were included in the study; and intraoperative findings were obtained and tabulated. Basic statistical analysis to compare means and Chi-square test for *P* value of complicated, noncomplicated, and mortality cases were used. **Results:** Patients who died scored a PATI mean of 27.16, while those who were complicated in general were 23.52, and the uncomplicated cases had a mean PATI of 10.48. **Conclusion:** Increasing the PATI score will increase the postoperative complications that can lead to death. This makes the PATI score >25 a risk factor for morbidity and mortality in penetrating abdominal trauma.

Keywords: Mortality, penetrating abdominal trauma index, postoperative complication

Introduction

Trauma remains the most common cause of death for all individuals between the ages of 1 and 44 years and the third-most common cause of death regardless of age. It is also the leading cause of years of productive life lost.[1-3]

After the invasion of Iraq in 2003 by coalition forces led by the US, the risk of death increased 2.5 folds when compared to the preinvasion period that is due to a violent death.[4,5]

While the cause of death in the acute and early period is due to central nervous system injuries and exsanguination, organ failure was the most common cause of late death (61%).[6-8]

To characterize injuries accurately for the purpose of clinical management, benchmarking, and research, several injury scoring systems have been developed. They typically are based on the anatomy of the injury or the resulting physiology, with several types of systems created and evaluated over the past 40 years.[9-11]

The penetrating abdominal trauma index (PATI) is a method of quantifying the risk of complication following penetrating abdominal trauma. A trauma index score was calculated by assigning a risk factor (1–5) to each organ injured and then multiplying this by a severity of injury estimate (1–5). The sum of the individual organ scores comprised the final PATI. The PATI score has a range of 0–200[12,13] as shown in the following table.

The injury severity score (ISS) is the anatomical scoring system most frequently used to assess the severity of whole-body trauma. The ISS is an established medical score to assess trauma severity. It correlates with mortality, morbidity, and hospitalization time after trauma.[14-16]

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Organ injured	Risk factor	Injury	Injury estimate
Duodenum	5	Single wall	1
		≤25% wall	2
		≤25% wall	3
		Duodenal wall and blood supply	44
		Pancreaticoduodenectomy	5
Pancreas	5	Tangential	1
		Through-and-through (duct intact)	2
		Major debridement or distal duct injury	3
		Proximal duct injury	4
		Pancreaticoduodenectomy	5
Large intestine	4	Serosal	1
		Single wall	2
		≤25% wall	3
		≤25% wall	4
		Colon wall and blood supply	5
Major vascular	4	≤25% wall	1
		≤25% wall	2
		Complete transection	3
		Interposition grafting or bypass	4
		Ligation	5
Spleen	3	Nonbleeding	1
		Cautery or hemostatic agent	2
		Minor debridement or suturing	3
		Partial resection	4
		Splenectomy	5
Kidney	3	Nonbleeding	1
		Minor debridement or suturing	2
		Major debridement	3
		Pedicle or major calyceal	4
		Nephrectomy	5
Extrahepatic biliary	2	Contusion	1
		Cholecystectomy	2
		≤25% common duct wall	3
		≤25% common duct wall	4
		Biliary enteric reconstruction	5
Small bowel	2	Single wall	1
		Through-and-through	2
		≤25% wall or 2–3 injuries	3
		>25% wall or 4–5 injuries	4
		Wall and blood supply or >5 injuries	5
Stomach	2	Single wall	1
		Through-and-through	2
		Minor debridement	3
		Wedge resection	4
		>35% resection	5
Ureter	2	Contusion	1
		Laceration	2
		Minor debridement	3
		Segmental resection	4
		Reconstruction	5
Bladder	1	Single wall	1
		Through-and-through	2
		Debridement	3
		Wedge resection	4
		reconstruction	5
Bone	1	Periosteum	1
		Cortex	2
		Through-and-through	3
		Intra-articular	4
		Major bone loss	5
Minor vascular	1	Nonbleeding small hematoma	1
		Nonbleeding large hematoma	2
		Suturing	3
		Ligation of isolated vessels	4
		Ligation of named vessels	5

The Abbreviated Injury Scale and the ISS are important tools for grading the severity of injury to trauma patients. The trauma chart provided is a simple and concise guide for scoring and recording this useful information.[17-19]

The highest incidence of postoperative complications is between 1 and 3 days after the operation. However, specific complications occur in the following distinct temporal patterns: early postoperative, several days after the operation, throughout the postoperative period, and in the late postoperative period.[20,21]

Common general postoperative complications include postoperative fever, atelectasis, wound infection, embolism, and deep-vein thrombosis.[22,23]

The postoperative complications observed are the ones that are serious and can lead to increased mortality which include postoperative hemorrhage, sepsis, multiple organ dysfunction syndrome, cardiac arrest and heart arrhythmias, acute respiratory distress syndrome (ARDS), deep-space wound infection, and evisceration.[24-26]

Aim of the study

This study aimed to evaluate patient outcomes in Al-Yarmuk Teaching Hospital regarding postoperative morbidity and mortality using the PATI score.

Patients and Methods

A cross-sectional study was done from April 2022 to April 2023 at Al-Yarmuk Teaching Hospital. Ninety-six patients who had penetrating abdominal injuries by bullets, shells, and stab wounds admitted to the emergency unit were candidates for the study. Eighty-one were male and 15 were female. The range of their age was 8–65 years. The patients are either transferred directly to the hospital or transferred from other hospitals to complete their surgical management. Patients are treated

initially in the emergency unit for stabilization according to the ATLS guidelines. Patients who had neurosurgical injuries were transferred to other hospitals to complete their management and thus excluded from the study. The ones who ended up with conservative or watchful treatment were excluded from the study as well as patients who died in the emergency unit or on the table.

After completion of the primary survey along with fluid therapy and preparation of blood and plasma, a detailed physical examination was obtained and necessary radiological ultrasound (US)/focused assessment with sonography for trauma (FAST) and computed tomography (CT) scan for the abdomen and pelvis were done for stable patients whenever available. Patients who had penetrating chest trauma along with signs of peritonism or unexplained shock were taken directly to the theater. The criteria to classify the patient as unstable include pulse rate > 120, blood pressure < 100, and disturbed level of consciousness. Diagnostic peritoneal lavage was not done as it is invasive and substituted by FAST to discover the presence of fluid, especially in stab wound injuries. CT scan was done in selected stable patients to delineate the extent of suspected organ injury, the patients enrolled in our study all had a laparotomy eventually.

At the theater, patients were explored by a midline incision, the injured organs were recorded, and the trauma index score was obtained according to the form of patient made for that reason. The patients have been followed up postoperatively for the whole period of hospitalization. Complications that were recorded were treated accordingly. Admission to the respiratory care unit was made with the help of an anesthetist in cases of ARDS, atelectasis, and pulmonary embolism, while those who developed organ failure as renal failure were treated at dialysis unit recommendations. Fistula and wound infection were treated successfully in the surgical ward under direct senior supervision.

Statistical analysis was done by the analysis of variance of means of PATI for complicated, noncomplicated, and death groups. The Chi-square test with *P* value and logistic regression model for prediction of mortality. The SPSS version 20 (SPSS Inc., Chicago, IL, USA) is a computerized system that has been used to obtain those data besides the basic statistical analysis values.

$P < 0.05$ is considered statistically significant.

Ethics approval

This study was approved by the ethical committee of the surgical Department of Al Yarmouk Teaching Hospital, Baghdad, Iraq, on 29 march 2023.To ensure adherence to ethical guidelines, several measures were adopted while conducting this study:

1. No incentives were offered to the participants in return for their participation.
2. Verbal consent was obtained from the participants before filling the questionnaire.
3. Participants were informed that their participation in this study is voluntary, no incentives or compensations will be offered in return, and that they have the right to withdraw from the study at any stage. The scientific value of their participation was explained in the verbal consent.
4. The contact information of the principal investigators was provided for participants.
5. All the participants' information was kept private by keeping it in a secured folder in a password-protected computer owned by the study investigators. No information was shared with any other individuals or entities.

Table 1: Distribution of female patients according to rate of injury

Age group in years	Blast	Bullet	Stab wound	Percentage from the total number
10–19	1	3	0	4.1
20–29	1	3	3	7.29
30–39	0	1	0	1.04
40–49	0	0	0	0
50–59	0	2	0	2.08
>60	1	0	0	1.04
Total	3	9	3	

Table 2: Distribution of male patients according to rate of injury

Age group	Blast	Bullet	Stab wound	Percentage from the total number
10–19	7	4	3	14.5
20–29	7	28	4	40.6
30–39	7	11	1	19.7
40–49	0	4	0	4.1
50–59	1	3	0	4.1
>60	0	1	0	1.04
Total	22	51	8	

Results

Ninety-six patients were enrolled in this study, who had exploratory laparotomy for penetrating abdominal trauma, 81 were male, while the female was 15, the mean age was 27.25 years, bullet injury accounted for 60 (62.5%) patients, shells 25 (26%), while stab wounds accounted only for 11 patients (11.45%) bullet scored as high injury percent in both males and females as shown in Tables 1 and 2, the incidence of injury was mainly to 20–29 age group in males and females while stab wounds injury in females scored as same as bullet [Tables 1 and 3]. Table 3 shows the details of our cases and their injuries with the resultant PATI.

Patients with stab wounds had a PATI of 2, while the bullet/shells group was 14.9.

Negative laparotomy was observed more in the stab wound group (36%), but only 2.3% in the bullet/shell group [Table 3].

Table 3: Distribution of patient male (n) according to the type of injury, fate, and death of the injured patient

Number	PATI	Age	Sex	Injury	Fate	Details of injury
1	32	25	Male	Bullet	Dead hemorrhage	Major liver debridement, ligation IVC
2	20	30	Male	Blast	Dead pulmonary embolism	<25 wall sigmoid, 4–5 injuries small bowel
3	8	32	Male	Bullet		Single-wall sigmoid
4	18	35	Male	Blast	Complicated wound infection	2–3 injuries small bowel, <25% wall descending colon
5	22	65	Female	Blast		<25% wall large bowel, wall and blood supply small bowel
6	18	31	Female	Bullet	Complicated fistula	Minor debridement stomach, <25% wall large bowel
7	20	25	Male	Bullet		<25% wall large bowel, single-wall bladder, 2 injuries small bowel
8	8	40	Male	Bullet		<25% wall small bowel, chest injury
9	0	24	Male	Blast		Negative laparotomy
10	22	31	Male	Bullet		Wall and blood supply small bowel, <25% transverse colon
11	12	25	Male	Bullet		<25% wall ascending colon
12	8	50	Male	Bullet		4 injuries small bowel
13	12	26	Male	Bullet		Ligation of isolated vessel, <25% small bowel
14	0	30	Male	Bullet		Negative laparotomy
15	6	30	Male	Bullet		Kidney suturing
16	8	32	Male	Bullet		4 injuries small bowel
17	31	27	Male	Blast	Intraabdominal abscess	Splenectomy, bleeding liver, 4–5 injuries of small bowel
18	10	19	Male	Stad wound		Bleeding liver, single wall stomach
19	0	23	Male	Stad wound		Negative laparotomy
20	4	15	Female	Blast		Single wall bowel, single wall stomach
21	8	37	Male	Bullet		Bleeding liver, diaphragm, chest tube
22	56	22	Male	Bullet	Hemorrhage/dead	Splenectomy, nephrectomy, through-and-through pancreas, >25% wall large bowel
23	4	22	Male	Bullet		Through-and-through small bowel
24	4	27	Male	Bullet		Single wall stomach, single wall small bowel
25	20	20	Female	Bullet		Colon wall and blood supply
26	24	63	Male	Bullet		>25% wall sigmoid, single wall ascending wall ascending
27	8	25	Male	Bullet		Bleeding liver, diaphragm
28	20	25	Female	Bullet		<25% large bowel, 5 injuries small bowel
29	28	32	Male	Blast		Ligation of common iliac v, >25% wall small bowel
30	18	12	Male	Bullet		Single wall stomach, lobectomy
31	14	12	Male	Blast		
32	11	30	Male	Blast		
33	6	27	Female	Bullet		
34	4	38	Male	Blast		
35	24	23	Male	Bullet		
36	0	22	Male	Stab wound		
37	21	25	Male	Bullet		
38	15	14	Male	Blast		
39	23	20	Male	Bullet		
40	20	15	Female	Bullet		
41	14	24	Male	Bullet		
42	2	24	Male	Stab wound		
43	0	34	Male	Bullet		
44	30	52	Male	Bullet		
45	0	31	Male	Stab wound		
46	0	25	Female	Stab wound		
47	0	24	Male	Stab wound		
48	28	20	Male	Bullet		
49	4	50	Female	Bullet		
50	3	24	Male	Bullet		
51	10	22	Male	Bullet		
52	15	10	Male	Blast		
53	26	28	Male	Bullet		

PATI: Penetrating abdominal trauma index, IVC: Inferior Vena Cava

Stab wounds are purely civilian, while the bullets/shells group was 60% military.

The most affected organs were the small and large bowel (for each one is 31.25%), the liver is the second-most affected (18.75%), and the stomach in the third place (12.5%), as shown in Table 4.

PATI in the complicated and noncomplicated group:

Patients who developed complications had a mean of PATI equals to 23.52 ± 14.29, while those who did not 10.48 ± 8.67, as shown in Table 5.

ANOVA test = 16.968, P = 0.007, which is considered statistically significant.

Table 4: Organ injury percentages

Organ	Number of patients (%)
Duodenum	1 (1.04)
Stomach	12 (12.5)
Pancreas	2 (2.08)
Liver	18 (18.75)
Large bowel	30 (31.25)
Major vessel	7 (7.29)
Spleen	10 (10.41)
Bone	2 (2.08)
Minor vessel	6 (7.29)
Kidney	9 (9.3)
Biliary	0
Ureter	1 (1.04)
Bladder	3 (3.12)
Small bowel	31 (31.25)

Table 5: The mean penetrating abdominal trauma index of complicated versus noncomplicated cases

	Number	Mean PATI	SD	95% CI from mean
Not complicated	75	10.84	8.67	8.88–12.80
Complicated (including dead)	21	23.52	14.29	17.00–30.03
Total	96			

SD: Standard deviation, CI: Confidence interval, PATI: Penetrating abdominal trauma index

Patients who scored 24.08 on PATI had an increased risk of complication and those who scored less had less risk of complication as shown in Table 6.

By the logistic regression model, people who scored 24.08 on PATI had an increased risk of complication by 1.105 times with those who scored less risk of complication as shown in Table 7.

The distribution of the PATI score, for patients who died, is illustrated in Table 8.

The mean PATI for the patients who survived was 11.68 ± 9.23, while for those who died was 27.16 ± 16.22, with the relevant 95% CI, as shown in Table 9.

By logistic regression model , those who scored more than 24 is 1.119 times risk of death than those who scored less (CL 95% =1.044–1.119) P value is 0.002 significance, as shown in Table 10.

Patients who developed serious postoperative complications are tabulated against those who developed the same complication but survived the P value = 0.001 which is calculated by using the Chi-square test as shown in Table 11.

Using Chi-square, the tabulated value in Table 11 is equal to P = 0.01–0.001, which is significant <0.05.

The cause of mortality in our sample has been spread against their corresponding PATI range to show that hemorrhage is the highest cause among the other causes as shown in Table 12.

Discussion

In this study, the patients who did not complicate scored a mean PATI of 10.84, the ones who had complications scored a mean PATI of 23.52, while those who died scored a mean PATI of 27.16, which are different from scores obtained in the study by Gomez Leon, which shows scores of 11.24 in the noncomplicated group, 21.47 in the complications group, and 25.29 in the death group. The difference can be due to different injuries caused by high-velocity bullets and shells in our study.[15]

In this study, the PATI below 5 shows no mortality at all in comparison to what Moore *et al*. showed that PATI below

Table 6: Distribution of patient according to their penetrating abdominal trauma index

PATI	Number of cases with complications including death	Percentage total	Percentage within group	Number of noncomplication cases	Percentage total	Percentage within group
0–5	1	1.04	4.76	26	27.08	34.67
6–15	5	5.2	23.8	27	28.13	36
16–25	7	7.29	33.33	18	18.75	24
26–35	6	6.25	28.58	4	4.17	5.33
36–45	0	0	0	0	0	0
46–55	0	0	0	0	0	0
56–65	2	2.8	9.52	0	0	0
Total	21			75		

PATI: Penetrating abdominal trauma index

Table 7: Logistic regression

	Wald test	df	*P*	Risk	95% CI for risk	
					Lower	Upper
PATI	12.453	1	0.000	1.105	1.046	1.169
Constant	24.868	1	0.000	0.060		

df: Degree of freedom, CI: Confidence interval, PATI: Penetrating abdominal trauma index

Table 8: Percentage and distribution of penetrating abdominal trauma index for mortality cases

PATI	Number of survived patients (%)	Number of death	Percentage of total (*n*)	Percentage within the group
0–5	27 (28.13)	0	0	0
6–15	32 (33.33)	4	4.17	12.5
16–25	25 (26.04)	3	3.12	12
26–35	10 (10.42)	3	3.12	30
36–45	0	0	0	0
46–55	0	0	0	0
56–65	2 (2.08)	2	2.08	100
Total	96	12		

PATI: Penetrating abdominal trauma index

Table 9: The mean penetrating abdominal trauma index for dead patients and alive patients

	n	Mean PATI	SD	95% CI for mean PATI
Survived	84	11.68	9.23	9.83–13.53
Death	12	27.16	16.22	23.91–30.40
Total	96			

CI: Confidence interval, SD: Standard deviation, PATI: Penetrating abdominal trauma index

Table 10: The risk predictive value for the patients

	Wald	df	*P*	Risk	95% CI for risk	
					Lower	Upper
PATI	10.069	1	0.002	1.119	1.044	1.199
Constant	23.943	1	0.000	0.019		

df: Degree of freedom, CI: Confidence interval, PATI: Penetrating abdominal trauma index

Table 11: Complication versus death

PATI	Total (*n*)	Survivors		Dead
		Noncomplicated	Complicated	
0–9	43	39	3	1
10–15	16	14	0	2
16–20	13	8	2	3
21–24	12	10	1	1
>25	12	4	3	5
Total	96	75	9	12

PATI: Penetrating abdominal trauma index

10 patients did not show complications; this is probably related to the associated vascular injuries in our patients.[5]

In this study, early death occurred with PATI below 25 because of concomitant cardiovascular injuries, and this is consistent with the timing and causes of death shown by Aldemir *et al.*, (2004).[16]

Eighty-one cases were male and 15 were female. The mean of their age was 27.40 ± 10.92 with a range of 10–62, which is different from a study by McLean and Hull in 2006 in which the age affected was 34.4 ± 11.9,[17] which can be attributed to the increased number of military causalities which involve this age group in Iraq. Bullet injuries accounted for 60 (62.5%) patients, shells were 25 patients (26%), and stab wounds were only 11 patients, which were purely civilian (11.45%).

The incidence of injuries was most in age 20–29 in both males and females reflecting the impact of war and violence on the economy and future of societies by affecting this important age group. Violence in comparison, on the other hand, is a leading cause of death in people aged 15–44 worldwide mentioned in the World Health Organization report.[18]

In this study, military injuries constituted the majority of cases of bullets and shells 60%, while stab wounds were purely civilian. The mean PATI score in stab wounds was 2, while in shells and bullets was 14.9 due to the high velocity and multi-organ involvement.

The most affected hollow abdominal organ with penetrating abdominal trauma in this study was the small and large bowel (31.25%); the same results were obtained in McLean and Hull (2006) research,[17] followed by the stomach (12.5%), while the most solid organ affected is liver injury (18.75%), and the spleen is in the second place (10.41).

The death occurred in 12 patients, two of them were female in comparison to the study of Mohammed *et al*., in which the female gender is considered an independent risk factor for mortality (insignificant $P = 0.4$).[19] The mean PATI of dead females was 40.5, while the mean PATI of dead males was 27.6.

Five cases of mortality scored >25 on PATI; the mean of PATI in the death group was 27.16 ± 16.22, with $P < 0.001$ in comparison to the survivor group.

By the logistic regression model, patients who scored >24 had a predictive risk of 1.119 than those who scored less.

Most of the mortality that occurred below the 25 score was due to concomitant vascular and cardiac injuries and the long duration between injury and arrival at the emergency department, especially in the case of military injuries which were about 60% of cases admitted, which is consistent with the study of Adesanya *et al*. in Turkey.[20]

Mortality with bullets and shells was higher than that with stab wounds, which is due to the multi-organ involvement, and more tract damage due to the high trajectory velocity and energy dispersed inside the body as shown by Narci *et al.* (2009).[21]

Table 12: Postoperative complication that led to mortality

PATI	No death	Septic shock	MODS	Arrhythmias	ARDS	Hemorrhage	Pulmonary embolism	Total
0–9	42					1		1
10–15	14			1		1		2
16–20	10		1			1	1	3
21–24	11						1	1
>25	7		1		1	3		5
Total	84		2	1	1		2	12

PATI: Penetrating abdominal trauma index, MODS: Multiple organ dysfunction syndrome, ARDS: Acute respiratory distress syndrome

The PATI of zero is due to negative laparotomies which accounted for 36% of stab wounds (four patients), while only 2.3% (two patients) in the bullet/shell group. This is consistent with the worldwide percentages if emergency operations done in stab wounds rather than selective management mentioned in the study of Dilege *et al.*, (2009)[22] which recommended patients who are stable to have FAST/US and or CT scan to delineate extent of injury. Local wound explorations under general anesthesia are further beneficial to define breach to the anterior rectus sheath which indicates the need for laparotomy; this should decrease the number of negative laparotomies.

The most common cause in the postoperative period that led to mortality was uncontrolled hemorrhage.

For the group that did not complicate, a PATI score of 10.84 ± 8.67 was recorded, and this is near the score in published literature by Kaymak *et al.*, (2016), which is 9.04 ± 3.39;[23] only 4.17% of cases above PATI of 25 did not complicate. While only (1.04%) complicated in the group scored below PATI of 5.

For this study, the complicated group scored a mean of 23.52 ± 14.29 with a predictive risk of 1.105 for each increase above 23 as shown in Table 7. In addition, eight patients have PATI >25 developed complication of which five have died, in comparison of what Rajab *et al*. showed in his study that increase of risk of morbidity 20 folds when PATI > 15.[24]

In this study, the age group of 10–19 years has three mortalities occurred. PATI was 15.20 and 61, the first two due to associated vascular injuries, while the rest of the group scored PATI < 25 and showed no mortality or morbidity making PATI the most important indicator found to be independently associated with morbidity in this age group as mentioned in the study of Williams *et al.*, (2004).[25]

In a study by ECe Rajab KK a colonic injury has been associated with an increased risk of both morbidity and mortality, especially when associated with other concomitant organ injuries.[26] In this study, 4.16% of the total number of patients had concomitant colonic and other organ injuries that showed morbidities and mortalities.

Factors such as high PATI, presence of shock, number of blood transfusions, and presence of concomitant organ injury can be an indication of the decision whether to repair the injury or make a stoma although AAST-AIS is more superior as mentioned by Kaymak *et al*.[23] in this study, the decision on making stoma or primary repair did not depend on PATI as control group could not be established. In the study of Dr. Kalid Kareem, the primary repair of colonic war injuries that are not destructive is safer than colostomies. The complications are more related to associated risk factors (high PATI, concomitant organ injury, and degree of contamination) than to the colonic injuries itself.[27]

Conclusion

Although a high PATI >25 is associated with an increased risk of postoperative morbidity and mortality, there is still a high risk of a low PATI score (<25) in cases when concomitant cardiovascular and severe liver injuries coexist. Those injuries need more extensive definitive repairs, which can take time and expertise, plus postoperative high-dependency units, which might not all be available in our hospital setting.

PATI is an independent variable for the prediction of morbidity and mortality, which means that it should be included with other risk factors to have the whole picture regarding patient outcomes.

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Conflicts of interest

There are no conflicts of interest.

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