

# Institutional differences in management of compartment syndrome at academic and community-based trauma centers: A survey of Orthopaedic Trauma Association (OTA) members

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## Abstract

**Objectives:** The purpose of this study was to compare management of compartment syndrome at academic and community trauma centers and to identify any institutional variables that influence the number of adverse events reported to the hospital's peer review process.

**Design:** Web-based survey.

**Setting:** N/A.

**Participants:** Orthopedic Trauma Association (OTA) members.

**Methods:** A link to a 9-item web-based questionnaire was sent to members of the OTA.

**Results:** Two hundred twenty-four (21%) of 1031 OTA members completed the survey. Respondents indicated that residents were primarily responsible for checking compartments at academic trauma centers (91%), while community trauma centers reported higher utilization rates of ortho attendings (81%), trauma attendings (26%), and nurses (27%). Seventy-five percent of respondents at academic trauma centers relied on intra-compartmental pressure monitoring to make the diagnosis in intubated/obtunded patients as opposed to just 56% of respondents at community centers. Seventy percent of all respondents utilizing prophylactic fasciotomies practiced at community trauma centers. Forty-four percent indicated that they had submitted cases involving management of compartment syndrome to their hospital peer review process. While most submitted only 1 or 2 cases (75% of positive replies), 5% had submitted 5 or more cases for peer review. Use of a pressure monitor and orthopaedic surgeons performing all fasciotomies were associated with a lower number of cases submitted to peer review ( $P < .02$  and  $P < .04$ , respectively).

**Conclusion:** Academic and community trauma centers differ in their utilization of in-house staff for early assessment, in the diagnostic modalities employed in obtunded patients, and in their threshold for fasciotomy. Adverse events are regularly reported for peer review at both academic and community trauma centers. As there is great variability between institutions in terms of clinical practice as demonstrated by the responses to this survey, it is recommended that institutions devise their own written protocol based on the resources they have available to reduce adverse events.

**Level of Evidence:** Therapeutic Level V.

**Keywords:** acute compartment syndrome, compartment syndrome, fasciotomy, missed compartment syndrome, OTA, Orthopaedic Trauma Association survey, compartment syndrome protocol

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## 1. Introduction

Missed or delayed diagnosis of compartment syndrome is associated with increased morbidity and long-term disability and is one of the most common sources of litigation for orthopaedic surgeons.<sup>[1]</sup> Previous Orthopedic Trauma Association (OTA) surveys have defined “best” care by establishing standards for treatment and diagnosis of compartment syndrome as described by expert opinion.<sup>[2]</sup> Eighty percent of those experts acknowledged cases of missed compartment syndrome at their own institutions, indicating that missed diagnosis may be more common than expected, even at established trauma centers. Considering the elusiveness of the diagnosis it becomes increasingly difficult to ascertain if clusters of adverse events are representative of institutional deficiencies requiring action, such as a formal written protocol, or are the expected consequence of an elusive diagnosis in a complex heterogenous patient population.

Despite a previous OTA survey of experts and clinical practice guidelines published by the American Academy of Orthopedic Surgeons (AAOS) to establish standards for management of compartment syndrome, uncertainty remains as to what day-to-day implementation of these “best” practices entails.<sup>[2,3]</sup> The goal of this study was to compare current practice patterns regarding management of compartment syndrome between academic and community trauma centers to further define “best care.” What strategies are being utilized to perform surveillance without resident support at community trauma centers? This study also evaluated institutional variables that contributed to the number of adverse events reported for hospital peer review to answer the following questions: Are adverse events more common in community trauma centers? At what point should an institution give consideration to adopting a written protocol to govern clinical practice in response to the number of adverse events? How often do other institutions formulate a written protocol or clinical practice guideline, and is there any data to demonstrate that a standardized approach is able to reduce the number of adverse events?

## 2. Methods

This study did not meet the criteria for research involving human subjects. A 9-item survey was developed by the author and submitted to the OTA Evidence Based Quality Value and Safety Committee. All OTA members received a link to the survey via

email. Survey responses were collected using Survey Monkey a free and secure web-based data entry system over a period of 5 months (January 2018 to June 2018).

Respondents were initially asked to identify their trauma center as level I, level II, community, or academic. Respondents were asked some general questions to ascertain how compartment syndrome is managed at their institution in terms of surveillance, indications for fasciotomy, and participation in peer review.

Multiple answer multiple choice questions were used to record answers. There were also 2 open-ended questions in the survey pertaining to participation in peer review. The data was recorded as percentages. Parametric (chi square) and nonparametric (Fisher exact) tests were used for the analysis of the statistical significance of the study data.

## 3. Results

In total, 224 (21%) of the 1031 OTA members responded to the survey. Over 99% of respondents answered all 9 questions. Fifty-four percent of respondents practiced at academic trauma centers, 49% at academic level I centers, and 5% at academic level II centers. Forty-one percent practiced at community trauma centers, 11% at level I, and 30% at level II centers. Five percent responded “other” (a military hospital, a level III trauma center, and a community hospital). Survey responses at community and academic trauma centers are compared in Table 1.

**Table 1**

**Survey responses are compared between respondents at Academic and Community Trauma Centers**

	Academic trauma	Community trauma
Q 1. What Kind of Trauma Center to you Practice At?	121(54%)	92 (41%)
Q 2. Institutions with Written Guidelines for Management	34 (28%)	17 (18%)
Q 3. At your Institution Who is Responsible for Performing Compartment Checks?		
Orthopaedic Resident	111 (92%)	15 (16%)
Orthopaedic Attending	38 (31%)	75 (81%)
Trauma Attending	16 (13%)	24 (26%)
Orthopaedic PA	26 (21%)	40 (43%)
RN	13 (10%)	25 (27%)
Trauma PA	5 (4%)	13 (14%)
Q 4. What Type of Surveillance Plan Utilized on Intubated/Obtunded Patients		
Continuous Pressure Monitoring	2 (2%)	4 (4%)
ICP every 2 h	13 (10%)	6 (7%)
ICP every 6 h	4 (3%)	2 (2%)
Baseline ICP, Repeat ICP only with change in manual exam	54 (45%)	34 (37%)
Manual Physical Exam Daily	28 (23%)	27 (29%)
Prophylactic Fasciotomy	3 (2%)	9 (10%)
None	0 (0%)	6 (7%)
Other	17 (14%)	6 (7%)
Q 5. Which of the Following is an Indication for Fasciotomy?		
ICP ≥ 30 mm Hg	21 (18%)	28 (31%)
ICP ≥ 40 mm Hg	22 (18%)	19 (21%)
Warm Ischemia > 4 h	51 (42%)	40 (43%)
Warm Ischemia > 6 h	60 (49%)	41 (44%)
Unknown Warm Ischemia	72 (60%)	54 (59%)
ΔP ≥ 30 mm Hg	112 (93%)	82 (89%)
Other	17 (14%)	10 (11%)
Q 6. Who is responsible for Fasciotomy at your Institution?		
Trauma UE and LE	37 (31%)	15 (16%)
Trauma LE only	18 (15%)	8 (9%)
Ortho Does All	51 (42%)	42 (46%)
Ortho Only with Associated Fracture or Joint Dislocation	41 (34%)	37 (40%)
Plastics UE only	20 (17%)	8 (9%)
Vascular UE and LE	22 (18%)	21 (23%)
Vascular LE only	36 (30%)	17 (18%)

Twenty-three percent of respondents indicated that their trauma center had a written clinical practice guideline/protocol for compartment syndrome and 76% responded that their center did not. One percent responded that their institution was currently drafting a written clinical practice guideline as part of a quality improvement process. Twenty-eight percent of academic trauma centers had a written protocol/clinical practice guideline as compared with 18% of community trauma centers.

Surveillance for alert/awake patients was performed by an orthopaedic resident in 59% of centers, an ortho attending in 52%, an orthopaedic physician assistant (PA) in 31%, a trauma attending in 18%, a trauma resident in 12%, a trauma PA in 8%, and a registered nurse in 18%. Fifty-seven percent indicated that surveillance of intubated/obtunded patients was the responsibility of an orthopaedic resident, 51% responded orthopaedic attending, 30% responded orthopaedic PA, 20% responded trauma attending, 14% responded trauma resident, 8% responded trauma PA, and 16% responded registered nurse.

Sixty-six percent of respondents indicated that surveillance for compartment syndrome in intubated or obtunded patients included pressure monitoring. Three percent performed continuous pressure monitoring, 9% performed serial pressure monitoring every 2 hours, 3% performed serial pressure monitoring every 6 hours, 40% performed serial pressure monitoring initially to establish a baseline and repeated only if a change was detected on manual examination, 26% performed a manual examination daily, 6% performed prophylactic fasciotomy in patients at risk, 12% indicated other, and 2% indicated that they did not perform surveillance in these patients. Intracompartmental pressure monitoring (ICP) was performed in intubated/obtunded patients by 75% of respondents at academic centers but only by 56% of respondents at community centers. Seventy percent of respondents who utilized prophylactic fasciotomy in lieu of a surveillance plan practiced at a community trauma center.

Ninety-one percent of respondents used delta P less than 30 as appropriate indication for fasciotomy; 24% used an absolute pressure greater than 30 mm Hg; 19% used an absolute pressure greater than 40 mm Hg; 43% used a warm ischemia time of more than 4 hours; 46% used a warm ischemia time of more than 6 hours 4, 58% considered unknown ischemia time was an indication for fasciotomy, and 12% reported other.

Sixty-six percent of respondents indicated that surgical management of compartment syndrome was undertaken by multiple subspecialties outside orthopaedics. Twenty-three percent of respondents indicated that trauma surgeons performed fasciotomies on both the upper and lower extremities, 20%

responded that vascular surgeons performed fasciotomies of the upper and lower extremities, and 13% reported that plastic surgeons performed upper extremity fasciotomies at their institution. Forty-four percent reported that orthopaedic surgeons performed all fasciotomies at their institution. Trauma surgeons at academic centers were almost twice as likely as their counterparts at community centers to perform fasciotomies in both the upper and lower extremity (31% to 16%). This trend was not observed among vascular surgeons or plastic surgeons.

Forty-four percent of respondents indicated that they had sent cases of management of compartment syndrome (involving missed or delayed diagnosis) to their hospital's peer review process. Nineteen percent indicated that they had submitted cases involving surgical error during fasciotomy to peer review (Table 2). Univariate analysis using parametric (chi-square) and nonparametric (Fishers exact) tests showed a significant association of having orthopaedic surgeons perform all fasciotomies and use of pressure monitors with a reduction in the number of cases of compartment syndrome submitted to peer review (Table 3). At academic trauma centers this correlation was stronger when an all orthopaedic approach ( $P = .017$ ) or pressure monitor ( $P = .013$ ) was used. At community trauma centers only the existence of a written protocol correlated with a lower number of cases submitted to peer review ( $P < .018$ ; Table 4). No significant correlation was found for any variable among respondents who indicated that they sent cases of technical errors when performing fasciotomies (incomplete release or neurovascular injury) to their hospital's peer review system (Table 5).

#### 4. Discussion

Compartment syndrome is an important topic that is often discussed at trauma centers. A previous OTA survey of experts and a recent AAOS clinical practice guideline were able to establish some standards for treatment and diagnosis of compartment syndrome; however, the extent to which these standards are implemented is unclear.<sup>[2,3]</sup> Our goal was to compare clinical practice at academic and community trauma centers to see if there were any institutional differences, and to describe the impact of those differences on the number of adverse events reported to peer review. Trauma centers differed in their utilization of in-house staff for early assessment, use of modalities for diagnosis in obtunded patients, and in their threshold for fasciotomy. Adverse events were reported with regularity at both academic and community trauma centers.

**Table 2**  
**Response summary of academic and community trauma centers with regard to number of cases submitted to peer review for management of compartment syndrome and surgical error during fasciotomy**

	Respondents who submitted cases to peer review regarding management of compartment syndrome	Respondents who submitted cases to peer review regarding surgical error with fasciotomy
Academic trauma centers		
None	59	93
1–2 Cases	43	23
3–4 Cases	7	4
> 4 Cases	11	0
Community trauma centers		
None	55	79
1–2 Cases	32	14
3–4 Cases	2	2
> 4 Cases	6	0

**Table 3**  
Univariate association with compartment syndrome management cases sent to peer review

Covariate	Statistics	Level	No N=119	Yes N=101	Parametric P value*	Nonparametric P value†
Type	N (Row %)	Academic	59 (49.17)	61 (50.83)	.051	.055
	N (Row %)	Community	55 (57.89)	40 (42.11)		
	N (Row %)	Other	5 (100)	0 (0)		
Designation	N (Row %)	Level I	65 (48.87)	68 (51.13)	.138	.138
	N (Row %)	Level II	49 (61.25)	31 (38.75)		
	N (Row %)	Other	5 (71.43)	2 (28.57)		
Service	N (Row %)	Multidisciplinary	63 (47.73)	69 (52.27)	.020	.027
	N (Row %)	Ortho All	56 (63.64)	32 (36.36)		
Number of QI Cases	N (Row %)	1 to 2	0 (0)	75 (100)		
	N (Row %)	3 to 4	0 (0)	9 (100)		
	N (Row %)	>4	0 (0)	17 (100)		
Written_Protocol	N (Row %)	No	95 (56.21)	74 (43.79)	.328	.293
	N (Row %)	Other	0 (0)	1 (100)		
	N (Row %)	Yes	24 (48)	26 (52)		
Stryker_Device	N (Row %)	No	55 (62.5)	33 (37.5)	.041	.053
	N (Row %)	Yes	64 (48.48)	68 (51.52)		
Continuous Pressure Monitoring	N (Row %)	No	112 (52.83)	100 (47.17)	.053	.073
	N (Row %)	Yes	7 (87.5)	1 (12.5)		

\* The parametric P value is calculated by chi-square test.

† The nonparametric P value is calculated by Fisher exact test.

The most obvious difference between academic and community trauma centers lies in the availability of residents at academic centers to perform compartment checks. Ninety-one percent of respondents at academic trauma centers indicated that residents were responsible for compartment checks as opposed to 17% at community centers. Centers with residents that take in-house call have a key strategic advantage in management of compartment syndrome because of their availability to assess patients and perform serial examinations. Community trauma centers that lack this in-house orthopaedic service would need to rely on the support of mid-level providers, nurses, or other in-house physicians to have the same key advantage. This survey found that the rate of utilization of nurses and trauma attendings for compartment checks was higher at community trauma centers than at academic centers (26%–27% vs 10%–13%). Although the role of nursing in assessing ICP in obtunded patients is not clearly defined, relying on in-house resources to check compartments may be an effective way of reducing delays and improving outcomes.

The AAOS clinical practice guidelines and the OTA survey of experts both recommend pressure monitoring to make the diagnosis of compartment syndrome in obtunded patients.<sup>[2,3]</sup> In our survey, 75% of respondents at academic centers utilize ICP in intubated/obtunded patients whereas only 56% of respondents did so at community centers. This difference may be attributed to limited availability of in-house resources to measure ICP at community trauma centers. Most common response indicated a pressure monitor was used to record ICP at baseline, with repeat ICP performed only if a change was detected on examination. Prophylactic fasciotomy was used in lieu of a surveillance plan more often in community centers than in academic centers, which again reflects the need for additional support at community trauma centers due to lack of in-house resources.

Making the diagnosis of compartment syndrome in an obtunded/intubated patient can be a challenge. In agreement with the recent OTA expert panel report, 91% of our survey respondents used the delta P as an indicator to make the diagnosis

**Table 4**  
Univariate association with compartment syndrome management cases sent to peer review (community trauma centers only)

Covariate	Statistics	Level	No N=55	Yes N=40	Parametric P value*	Nonparametric P value†
Designation	N (Row %)	Level I	14 (56)	11 (44)	.229	.298
	N (Row %)	Level II	41 (60.29)	27 (39.71)		
	N (Row %)	Other	0 (0)	2 (100)		
Service	N (Row %)	Multidisciplinary	31 (55.36)	25 (44.64)	.548	.673
	N (Row %)	Ortho All	24 (61.54)	15 (38.46)		
Number of QI Cases	N (Row %)	1 to 2	0 (0)	32 (100)		
	N (Row %)	3 to 4	0 (0)	2 (100)		
	N (Row %)	>4	0 (0)	6 (100)		
Written_Protocol	N (Row %)	No	50 (63.29)	29 (36.71)	.018	.026
	N (Row %)	Yes	5 (31.25)	11 (68.75)		
Stryker_Device	N (Row %)	No	27 (57.45)	20 (42.55)	.930	1.000
	N (Row %)	Yes	28 (58.33)	20 (41.67)		
Continuous Pressure Monitoring	N (Row %)	No	52 (57.14)	39 (42.86)	.479	.636
	N (Row %)	Yes	3 (75)	1 (25)		

\* The parametric P value is calculated by chi-square test.

† The nonparametric P value is calculated by Fisher exact test.

**Table 5**  
**Univariate association with surgical error cases sent to peer review**

Covariate	Statistics	Level	No N=177	Yes N=43	Parametric P value*	Nonparametric P value†
Type	N (Row %)	Academic	93 (77.5)	27 (22.5)	.313	.451
	N (Row %)	Community	79 (83.16)	16 (16.84)		
	N (Row %)	Other	5 (100)	0 (0)		
Designation	N (Row %)	Level I	101 (75.94)	32 (24.06)	.077	.094
	N (Row %)	Level II	69 (86.25)	11 (13.75)		
	N (Row %)	Other	7 (100)	0 (0)		
Service	N (Row %)	Multidisciplinary	104 (78.79)	28 (21.21)	.445	.491
	N (Row %)	Ortho All	73 (82.95)	15 (17.05)		
N_Cases_SE	N (Row %)	1 to 2	0 (0)	37 (100)		
	N (Row %)	3 to 4	0 (0)	6 (100)		
Written_Protocol	N (Row %)	No	136 (80.47)	33 (19.53)	.123	.280
	N (Row %)	Other	0 (0)	1 (100)		
	N (Row %)	Yes	41 (82)	9 (18)		
Stryker_Device	N (Row %)	No	74 (84.09)	14 (15.91)	.267	.301
	N (Row %)	Yes	103 (78.03)	29 (21.97)		
Continuous Pressure Monitoring	N (Row %)	No	171 (80.66)	41 (19.34)	.692	.656
	N (Row %)	Yes	6 (75)	2 (25)		

\* The parametric P value is calculated by chi-square test.

† The nonparametric P value is calculated by Fisher exact test.

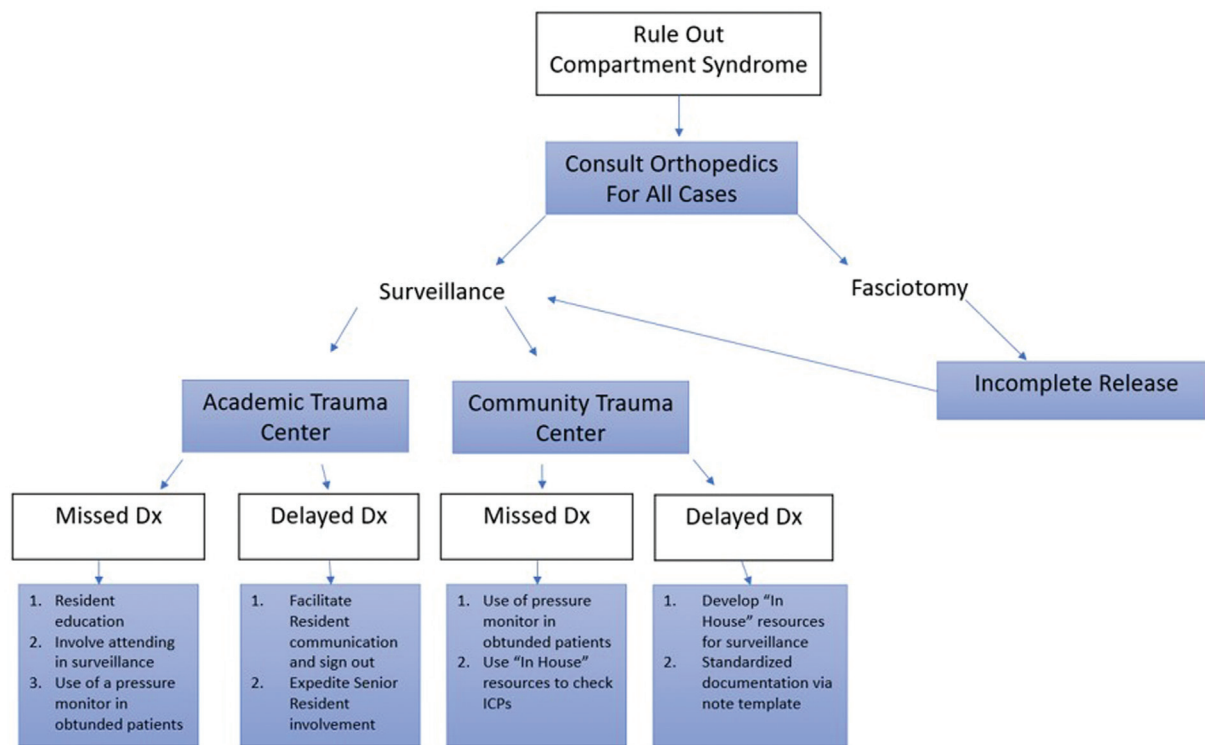
in obtunded patients.<sup>[2]</sup> Despite several articles outlining the pitfalls of using an absolute pressure of 30 mm Hg for diagnosis, 24% still used an absolute pressure of 30 mm Hg as a threshold for fasciotomy in clinical practice.<sup>[4,5]</sup> The percentage was higher among respondents who practiced at community level II trauma centers than those working in academic level I centers (31% vs 18%) respectively. This bias toward lower thresholds for fasciotomy is also reflected in the number of respondents who utilized prophylactic fasciotomies in lieu of a surveillance plan; 70% of these respondents also practiced at community trauma centers. Considering the impact of fasciotomy on infection and length of stay, this may not be the best approach and adopting a formal written institutional guideline may help curb this practice if it is felt to be over utilized. Respondents to our survey at community trauma centers with a written protocol for compartment syndrome did not perform prophylactic fasciotomies as an alternative to surveillance.

In our survey adverse events were reported regularly at both academic and community trauma centers. Forty-four percent indicated that they had submitted cases of compartment syndrome to their own hospital peer review process. Only 19% of respondents reported technical errors during fasciotomy. Typically 1 to 2 cases were reported to peer review (75% of positive replies), with only 5% of all respondents reporting 5 or more cases. As 95% of our respondents submitted fewer than 5 cases, this number may represent a threshold of significance by which institutions have deviated from the expected standard for clinical outcomes and should be considered outliers. A cluster of 5 or more cases of missed or delayed diagnosis is unlikely to reflect elusiveness of the diagnosis, and more likely to reflect institutional deficiencies in clinical practice requiring intervention. Several respondents to our survey indicated they were using the number of peer review cases as justification for a written protocol at their own institution.

The benefit of a standardized written approach in the management of compartment syndrome is controversial.<sup>[6-8]</sup> Given the challenges involved in the diagnosis of this clinical syndrome, a written algorithm has never been reliably shown to increase the sensitivity of clinical examination thereby reducing the risk of a missed diagnosis.<sup>[9-11]</sup> Furthermore, adopting a

uniform surveillance plan may not be appropriate in every clinical circumstance, considering the heterogeneity of the patient population involved, as demonstrated by the variability in responses to our survey. Previous attempts to devise protocols may have been misguided in their attempts to govern aspects of clinical practice that are best kept flexible. A paradigm shift from a treatment-based algorithm to a problem-based one would likely make written protocols more effective. Instead of developing a treatment-based algorithm that dictates specifics of clinical practice with the goal of changing treatment, a problem-based algorithm would modify local institutional variables with the goal of reducing adverse events. From a medical-legal standpoint several studies have demonstrated decreased legal indemnity by reducing delays in diagnosis and reducing inconsistencies in documentation.<sup>[12-14]</sup> A problem-based institutional protocol could target delays in the system to improve outcomes while avoiding specific aspects of clinical practice for which there is a lack of agreement among clinicians. Moreover, in our study the only variables found to decrease the number of cases submitted to peer review were having orthopaedic surgeons responsible for all fasciotomies rather than a multi-subspecialty approach, and use of a pressure monitor on obtunded or intubated patients ( $P < .04$  and  $P < .02$  respectively). At institutions with a high number of adverse events, enhanced outcomes may be achieved by adopting a culture whereby orthopaedics is consulted and involved for all cases of compartment syndrome. A problem-based institutional clinical practice guideline to improve outcomes is outlined in the algorithm shown in Figure 1.

Despite some of the pitfalls and controversies surrounding written protocols, 28% of respondents at academic centers and 18% of those at community centers still acknowledged their institution had a written protocol for management. Although less common at community trauma centers, institution-based practice guidelines may be more effective in reducing adverse events. At community centers, the presence of a written protocol correlated with a lower number of cases submitted to peer review ( $P < .018$ ). In view of the previously stated differences between academic and community trauma centers, institution-specific written protocols should be developed to accommodate for these differences (Fig. 1).



**Figure 1.** A problem-based algorithm for management of compartment syndrome modifies local institutional variables with the goal of reducing adverse events as opposed to a treatment-based algorithm that dictates the specifics of clinical practice with the goal of changing treatment.<sup>[11–14]</sup>

This study had several limitations. Only 22% of the OTA members responded to the survey which is consistent with participation in other surveys of OTA members.<sup>[15–17]</sup> There was considerable variability in the responses concerning management of compartment syndrome which likely reflects the complexity of this patient population. The number of cases submitted to peer review has never before been used as a metric to evaluate clinical practice patterns, and does not necessarily equate to adverse outcomes. Due to the sensitive nature of the diagnosis, a retrospective multicenter review of medical records would likely be unable to recreate any usable data on this topic.<sup>[18]</sup> In view of the medico-legal implications associated with delayed diagnosis, an anonymous survey is the safest avenue by which accurate data can be analyzed while completely protecting the respondents from indemnity.

In conclusion, although clinical practice recommendations from the OTA and AAOS are helpful in outlining “best practice” for diagnosis and treatment for compartment syndrome, adverse events are still reported regularly at both academic and community trauma centers. A cluster of 5 or more cases of missed/delayed diagnosis is more likely to be a consequence of institutional deficiencies in clinical practice requiring intervention than the elusiveness of the diagnosis. As there is great variability between institutions in terms of clinical practice as demonstrated by the responses to this survey, it is recommended that institutions devise their own written protocol based on the resources they have available to reduce adverse events. This problem-based written approach must be carefully cultivated to avoid mandating specifics of clinical practice that are not appropriate in every clinical circumstance. Academic and community trauma centers differ in their utilization of in-house staff for early assessment, in their use

of modalities for diagnosis in obtunded patients, and in their threshold for fasciotomy. Written clinical practice guidelines may be more effective if they adopt a problem-based approach to reduce delays while acknowledging these institutional differences.

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