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# A multicenter study of acute testicular torsion in the time of COVID-19

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## Keywords

Testicular torsion; COVID-19; Pandemic; Urologic emergencies

## Abbreviations

ED, Emergency Department; OR, Operating Room; CDC, Centers for Disease Control; COVID-19, Coronavirus disease 2019

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## Summary

### Background

Testicular torsion is a surgical emergency, and time to detorsion is imperative for testicular salvage. During the COVID-19 pandemic, patients may delay emergency care due to stay-at-home orders and concern of COVID-19 exposure.

### Objective

To assess whether emergency presentation for testicular torsion was delayed during the COVID-19 pandemic, and whether the rate of orchiectomy increased compared to a retrospective period.

### Study design

Patients were prospectively enrolled in a multicenter study from seven institutions in the United States and Canada. Inclusion criteria were patients two months to 18 years of age with acute testicular torsion from March through July 2020. The retrospective group included patients from January 2019 through February 2020. Statistical analysis was performed using Kruskal–Wallis tests, Chi-square tests, and logistic regression.

### Results

A total of 221 patients were included: 84 patients in the COVID-19 cohort and 137 in the retrospective

cohort. Median times from symptom onset to emergency department presentation during COVID-19 compared to the retrospective period were 17.9 h (IQR 5.5–48.0) and 7.5 h (IQR 4.0–28.0) respectively ( $p = 0.04$ ). In the COVID-19 cohort, 42% of patients underwent orchiectomy compared to 29% of pre-pandemic controls ( $p = 0.06$ ). During COVID-19, 46% of patients endorsed delay in presentation compared to 33% in the retrospective group ( $p = 0.04$ ).

### Discussion

We found a significantly longer time from testicular torsion symptom onset to presentation during the pandemic and a higher proportion of patients reported delaying care. Strengths of the study include the number of included patients and the multicenter prospective design during the pandemic. Limitations include a retrospective pre-pandemic comparison group.

### Conclusions

In a large multicenter study we found a significantly longer time from testicular torsion symptom onset to presentation during the pandemic and a significantly higher proportion of patients reported delaying care. Based on the findings of this study, more patient education is needed on the management of testicular torsion during a pandemic.

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**Summary Table** Demographic and baseline characteristics of acute testicular torsion patients.

	COVID-19 cohort (n = 84) Median (IQR) or N (%)	Retrospective cohort (n = 137) Median (IQR) or N (%)	P value*
Time from onset of symptoms to ED (hours)	17.9 (5.5–48)	7.5 (4.0–28)	0.04
Time from onset to presentation >6 h	54 (68)	79 (59)	0.17
Time from onset to presentation >12 h	42 (53)	53 (40)	0.05
Time from onset to presentation >24 h	33 (42)	37 (28)	0.03
Delayed seeking care <sup>§</sup>	39 (46)	45 (33)	0.04
Orchiectomy	34 (43)	40 (29)	0.06

\*P values from Kruskal–Wallis test or Chi-square test.

<sup>§</sup>Not all patients from the COVID cohort indicated that the delay in seeking care was due to COVID.

## Introduction

Acute testicular torsion is a common pediatric emergency with an incidence of 4.5 per 100,000 males per year in the United States and most frequently occurring between 10 and 19 years of age [1]. Prompt diagnosis and surgical management with scrotal exploration and detorsion are important to prevent testicular loss. The likelihood of orchiectomy is time-dependent and can be avoided if surgical intervention occurs within the first 6 h following symptom onset [2]. Additionally, time from emergency department (ED) presentation to the operating room (OR) is an independent predictor of testicular survival [3].

During the 2020 coronavirus (COVID-19) pandemic, there has been increased avoidance of the ED for non-COVID-19 illnesses noted in news outlets and in the medical literature [4,5]. During the last week of June 2020, 41% of U.S. adults admitted to avoiding medical care because of COVID-19 exposure concerns and 12% avoided urgent or emergent care [6]. In the pediatric literature, reduced ED visits have been noted across all diagnosis categories in multiple countries during the COVID-19 pandemic [5,7,8] and reduced visits for complex chronic conditions were suggestive of ED avoidance behavior [8]. Notably, ED avoidance and delay has led to increased pediatric morbidity and mortality [7]. Furthermore, strict stay-at-home orders from local and state officials during peak community transmission of COVID-19 and strained medical resources, may also contribute to delays in both presentation and management of testicular torsion.

We hypothesize that patients may be delaying ED presentation for acute testicular torsion due to COVID-19 concerns. The primary objective of this study is to compare the time from symptom onset to ED presentation between pre-COVID and COVID cohort of pediatric patients. The secondary objective is to compare the orchiectomy rate between the same cohorts.

## Material and methods

### Patient selection

Pediatric patients who underwent scrotal exploration for acute testicular torsion were prospectively enrolled from

March through July of 2020 from seven pediatric hospitals in the U.S. and Canada. A second cohort of patients who underwent scrotal exploration for acute testicular torsion from January 2019 through February 2020 were identified retrospectively from each of the seven hospitals through the electronic medical records and served as the control group for comparison. The timing of the pandemic cohort was determined based on the CDC declaration of a pandemic on March 23, 2020. July 31, 2020 was selected *a priori* as the end date due to local schools reopening starting in August.

Inclusion criteria were patients between two months and 18 years of age with a diagnosis of acute testicular torsion and who underwent emergent scrotal exploration with detorsion orchiopexy or orchiectomy at the included institutions. Patients who did not have testicular torsion on surgical exploration, or were under two months of age (neonatal torsions) were excluded. Additionally, patients who underwent manual detorsion were excluded as return of blood flow could decrease the urgency of surgical management. Standard practice for surgical management at our included centers was scrotal exploration with detorsion orchiopexy versus orchiectomy depending on the viability of the torsed testis. Testicular fixation was performed with two- or three-point fixation with permanent suture of both the affected and contralateral testis. The primary outcome was time to ED presentation and secondary outcome was orchiectomy rate. We also examined parental endorsement of delaying presentation.

For both cohorts of patients, demographic data, information on transfer from another facility, dates and times of service, and indication of delay in seeking care from the onset of symptoms were recorded. At the pre-operative evaluation of the COVID-19 cohort, the urologist queried patients and their families on their knowledge of testicular torsion, if their presentation to the ED was delayed and if the delay was secondary to COVID-19 pandemic concerns. Orchiectomy versus detorsion orchiopexy was determined from the operative records. This study has received institutional review board approval, coordinating site IRB #: 200451. Study data were collected and managed using REDCap (Research Electronic Data Capture, Vanderbilt University, Nashville, TN) [9].

## Statistical analysis

Comparative analyses were performed with Kruskal–Wallis tests for continuous variables and Chi-square tests for categorical variables, as appropriate. Multivariable analysis was performed using logistic regression to compare orchiectomy risk in the COVID-19 group with the retrospective group while adjusting for the patient's age, race, ethnicity and transfer status. *P* values < 0.05 were considered significant. Statistical analyses were conducted using SAS Statistical Software (version 9.4; SAS Institute Inc., Cary, NC).

## Results

Table 1 displays the demographic and baseline characteristics of the patients in the COVID-19 and retrospective pre-COVID cohorts. The two groups did not differ significantly by age, race, ethnicity, or primary spoken language. A similar proportion of patients in the two groups were transferred from an outside center and the distance traveled from home to hospital was not significantly different.

The median time from onset of symptoms to ED presentation was significantly longer for the COVID-19 cohort (17.9 h (IQR 5.5–48)) than the retrospective cohort (7.5 h (IQR 4.0–28); *p* = 0.04) (Table 2). A higher proportion of patients waited over 24 h to present for care during COVID-19 compared to the retrospective period (42% vs 28%, *p* = 0.03). The median time from ED arrival to start time in the OR was similar in both groups (median values COVID-19 group: 2.8 h (IQR 2.1–3.7) versus retrospective group: 2.8 h (IQR 2.1–3.4)).

For the secondary outcome of orchiectomy, 42% (35/84) of patients from the COVID-19 group and 29% (40/137) of patients from the pre-COVID group underwent orchiectomy

(*p* = 0.06) (Table 2). Based on the unadjusted logistic regression model, patients in the COVID-19 cohort were 1.7 times as likely to undergo orchiectomy as pre-COVID controls but was just outside statistical significance (OR = 1.7, 95% CI 0.98–3.1, *p* = 0.06). In the multivariable logistic regression model adjusting for age, race, ethnicity and transfer status, the patients in the COVID-19 cohort were more likely to undergo orchiectomy than patients in the retrospective cohort, but the difference was not statistically significant (OR = 1.7, 95% CI: 0.93–3.1, *p* = 0.09).

Fig. 1 displays the rate of orchiectomy and median time from onset of symptoms to presentation for the COVID-19 cohort by month of the pandemic. The longest times to presentation were seen during March and April 2020, with decreases in time to presentation occurring by May 2020. The highest rates of orchiectomy were seen in March, April and July 2020.

We found that 46% of patients from the COVID-19 group indicated a delay in seeking care compared with 33% of the retrospective group (*p* = 0.04). Of the seven patients who reported delay in seeking care due COVID-19 concerns, the median time from symptom onset to presentation was 24 h (IQR 4.0–72). Other common reasons for delay were patients delaying telling parents about symptoms, symptoms starting in the middle of the night, incorrect diagnosis at an outside facility and trying to manage pain at home. Among patients in both groups with data available, only 5% indicated prior knowledge of testicular torsion (7/143).

## Discussion

Our results demonstrate that both time to presentation and outcomes for acute testicular torsion were impacted by the COVID-19 pandemic. We found that the time from symptom onset to presentation was significantly longer in

**Table 1** Demographic and baseline characteristics of acute testicular torsion patients during COVID-19 and patients from the retrospective period at seven pediatric centers (n = 221).

	COVID-19 cohort (n = 84) Median (IQR) or N (%)	Retrospective cohort (n = 137) Median (IQR) or N (%)	<i>P</i> value <sup>a</sup>
Age (years)	13.1 (10.7–14.7)	13.7 (11.6–15.2)	0.30
Distance traveled (miles)	18.0 (11–28)	15.0 (7.4–24)	0.10
Race			0.72
White	30 (36)	48 (35)	
Asian	10 (12)	10 (7.3)	
Black	6 (7.0)	6 (4.4)	
Other	5 (6.0)	9 (6.6)	
Unknown	33 (39)	64 (46.7)	
Ethnicity			0.52
Non-Hispanic	35 (42)	62 (45)	
Hispanic	35 (42)	47 (34)	
Unknown	14 (16)	28 (21)	
Primary language			0.25
English	58 (69)	107 (78)	
Spanish	21 (25)	26 (19)	
Other	5 (6)	4 (3)	
Transferred from another facility	36 (43)	62 (45)	0.89

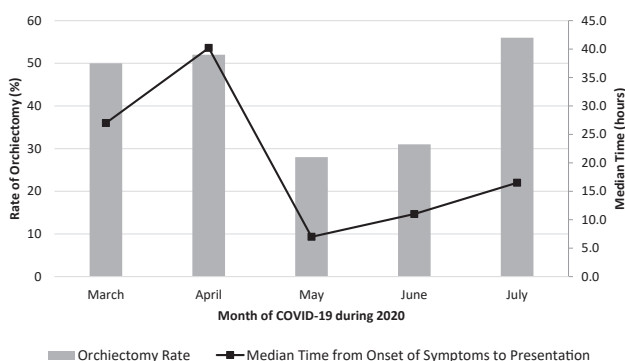
<sup>a</sup> *P* values from Kruskal–Wallis test or Chi-square test.

**Table 2** Comparison of clinical characteristics between acute testicular torsion patients from the COVID-19 cohort and patients from the retrospective cohort (n = 221).

	COVID-19 cohort (n = 84) Median (IQR) or N (%)	Retrospective cohort (n = 137) Median (IQR) or N (%)	P value <sup>a</sup>
Time from onset of symptoms to ED (hours)	17.9 (5.5–48)	7.5 (4.0–28)	0.04
Time from onset to presentation >6 h	54 (68)	79 (59)	0.17
Time from onset to presentation >12 h	42 (53)	53 (40)	0.05
Time from onset to presentation >24 h	33 (42)	37 (28)	0.03
Delayed seeking care <sup>b</sup>	39 (46)	45 (33)	0.04
Orchiectomy	34 (43)	40 (29)	0.06

<sup>a</sup> P values from Kruskal–Wallis test or Chi-square test.

<sup>b</sup> Not all patients from the COVID cohort indicated delay in seeking care due to COVID.



**Fig. 1** Distribution of patterns in acute testicular torsion presentation by month of the COVID-19 pandemic. Gray bars represent rate of orchiectomy by month, while the black line represents median time from onset of symptoms to presentation by month.

the COVID-19 cohort compared to the retrospective cohort. A higher orchiectomy rate was demonstrated among the COVID-19 group compared to the retrospective group, which may be an indirect effect of the pandemic due to an observed delay in seeking emergency care. This is the largest study of testicular torsion during COVID-19 and the first to show a significantly longer time from symptom onset to presentation. Patients in the COVID-19 cohort were also significantly more likely to endorse a delay in seeking care compared to retrospective controls, which further supports COVID-19 leading to indirect delays in care. Most notably, we found that patients during the COVID-19 pandemic had a 13% higher rate of orchiectomy at surgical exploration, although this was just beyond the level of statistical significance ( $p = 0.06$ ) and may be related to the power of the study. Other key factors were similar between the two groups: demographic characteristics, the transfer rate from outside hospital and median distance from home to hospital.

Similar to our findings, significant increases in delayed care for numerous other emergencies during the current pandemic, including pediatric surgical emergencies have been published [10,11]. A study of acute appendicitis from the New York Metropolitan region between March and May 2020 found a longer mean duration of symptoms and a significantly higher perforation rate compared to prior

years [11]. A more recent study of appendicitis in Virginia also found an increased perforation rate and pelvic abscesses requiring medical management during the pandemic [5]. It is interesting that we found a significantly longer time from symptom onset to ED presentation and a higher proportion of patients reporting delaying care, but the difference in orchiectomy rate was just outside the level of significance during COVID-19. This may be due to the high baseline rate of orchiectomy, making a significant difference in orchiectomy difficult to demonstrate and a variation in practice patterns for what a surgeon would consider to be a salvageable testis. We were unable to evaluate the post-operative atrophy rates on ultrasound due to length of follow-up.

The baseline rate of orchiectomy for testicular torsion is already high at 34% based on a large US study [1]. Similarly, low patient and family awareness of testicular torsion is very common with only 15–30% of patients having prior knowledge of torsion in survey studies [12,13]. In our study, this was even lower with only 5% (7/143) of patients having prior knowledge of torsion. Notably on prior studies of torsion awareness, the primary resource on torsion knowledge was a friend or family member who had testicular torsion; only 17% were informed of torsion by their pediatricians [12]. Low baseline awareness of torsion may contribute to delays in care that were present even before the pandemic, making patients and their families less likely to present for emergency care during the pandemic when there is concern for exposure to COVID-19.

We recognize that at baseline prior to the pandemic, some children have delayed presentation to the ED for acute testicular torsion. Bayne et al. (2017) found that 13% of children with torsion may delay informing their parents and that children with autism spectrum disorders are at higher risk of delayed presentation [14]. However, we anticipate that the baseline delay of presentation for acute testicular torsion to the ED remained stable between the pandemic and retrospective control cohorts. Hospital transfer to tertiary care centers also increases time from symptom onset to OR and has a negative impact on testicular salvage [15]. However, we demonstrated that the transfer rate was nearly identical between the COVID-19 and control cohorts (43% and 45%, respectively). Therefore, hospital transfers likely did not impact the effect of COVID-19 and emergency care avoidance on testicular torsion presentation and orchiectomy rates.



We also examined time from ED presentation to OR start time as this interval has been shown previously to be an independent predictor of testicular salvage [3]. Many centers have testicular torsion protocols to expedite ED presentation to OR time but during the pandemic, rapid COVID testing needed to be performed prior to patients undergoing surgery. There was some concern that rapid COVID testing could extend the time from ED presentation to OR incision time. However, we found that this time interval was not different between the COVID-19 cohort and pre-pandemic controls. Furthermore, preoperative testing for COVID-19 has numerous benefits for the patient, staff and resource utilization with only a potential slight increase in ED presentation to OR time. In this case, the increase in orchiectomy rate is most likely secondary to delayed presentation and not COVID testing extending door to OR start time.

Our findings differ from the other published studies on testicular torsion during COVID-19. The prior studies were both single center studies during the early months of the COVID-19 pandemic and did not find any difference in time from symptom onset to ED presentation [16,17]. The orchiectomy rate was higher in the COVID-19 group (of 17 torsion patients) but not significantly different from the comparison group in Nelson et al. 2020; there was no difference in orchiectomy rate in Littman et al. 2021 with a COVID-19 group of 21 patients [16,17]. We anticipate that the discordance between our results may be due to our larger sample size of 84 patients with testicular torsion during COVID-19. Furthermore, the prior studies collected COVID-19 torsion patients from only March through May of 2020 while our study continued through July and higher infection rates were seen in the majority of our region during the summer months. Interestingly in our study, the longest times to presentation and highest orchiectomy rates during the pandemic were during the beginning of the pandemic with a second increase in orchiectomy rate in July when cases were rising (Fig. 1).

Our study has several strengths including the large number of patients, multicenter design, and prospective collection of torsion cases during COVID-19. We also have the most long-term study on testicular torsion during COVID-19 and examined outcomes when infection levels were higher throughout most of the country. However, our study has several limitations. Our included centers have a similar patient base of suburban and urban patients; however, we do not have a center with a high proportion of rural patients. Therefore, our results may not be generalizable to a rural practice setting. Rural patients may have a longer time between symptom onset and presentation due to transportation time and the effect of COVID-19 may be less prominent. In a California state-wide retrospective study of torsion, rural patients had a higher incidence of orchiectomy on univariate analysis but not multivariate analysis [18].

A contemporary prospective control cohort would have improved our study, but this was not possible because it is unclear when the pandemic will conclude. We urgently wanted to have this information available to stress the importance of patient education particularly as the pandemic has continued unabated with high numbers of cases and deaths. It was difficult to pinpoint when COVID-19

concerns would have the greatest impact on the studied population. We chose to start our prospective COVID-19 arm of the study on March 23, 2020 when the CDC declared COVID-19 a pandemic. Prior studies from the northeast and southeast regions have used March through May 2020 [11,16]; however, the case rate was higher in the summer for certain parts of the West Coast, where many of our centers reside. It was difficult to account for changes in patients' attitudes and fear of COVID as the pandemic has progressed.

We plan to continue the study as the pandemic progresses. Although the increased orchiectomy rate was not statistically significant, we will monitor the atrophy rate in post-orchiopexy ultrasounds among the patients who underwent testicular salvage during COVID-19 who had a delay in presentation. We will also examine the potential effects of coronavirus restrictions adherence fatigue in future studies, as patients experiencing adherence fatigue may be less likely to avoid the hospital setting.

## Conclusions

Our findings clearly demonstrate that the COVID-19 pandemic has affected outcomes and time to presentation for acute testicular torsion in seven centers in the U.S. and Canada. These results are especially impactful given that the COVID-19 pandemic continues to surge, and the effect of newly identified variants remains uncertain. Increased patient and family education on testicular torsion is vital but remarkably so during a time when the pandemic is far from concluding and testicular emergencies will continue.

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## Conflicts of interest

The authors have no conflicts of interest to report.

## References

- [1] Mansbach JM, Forbes P, Peters C. Testicular torsion and risk factors for orchiectomy. *Arch Pediatr Adolesc Med* 2005;159:1167–71.
- [2] Pogorelič Z, Mrklič I, Jurić I, Biočić M, Furlan D. Testicular torsion in the inguinal canal in children. *J Pediatr Urol* 2013;9:793–7.
- [3] Gold DD, Lorber A, Levine H, Rosenberg S, Duvdevani M, Landau EH, et al. Door to detorsion time determines testicular survival. *Urology* 2019;133:211–5.
- [4] Lange SJ, Ritchey MD, Goodman AB, Dias T, Twentyman E, Fuld J, et al. Potential indirect effects of the COVID-19 pandemic on use of emergency departments for acute life-threatening conditions - United States, January-May 2020. *Am J Transplant* 2020;20:2612–7.
- [5] Place R, Lee J, Howell J. Rate of pediatric appendiceal perforation at a children's hospital during the COVID-19

- pandemic compared with the previous year. *JAMA Netw Open* 2020;3:e2027948.
- [6] Czeisler ME, Marynak K, Clarke KEN, Salah Z, Shakya I, Thierry JM, et al. Delay or avoidance of medical care because of COVID-19-related concerns - United States, June 2020. *MMWR Morb Mortal Wkly Rep* 2020;69:1250–7.
- [7] Lazzarini M, Barbi E, Apicella A, Marchetti F, Cardinale F, Trobia G. Delayed access or provision of care in Italy resulting from fear of COVID-19. *Lancet Child Adolesc Health* 2020;4:e10–1.
- [8] McDonnell T, Nicholson E, Conlon C, Barrett M, Cummins F, Hensey C, et al. Assessing the impact of COVID-19 public health stages on paediatric emergency attendance. *Int J Environ Res Publ Health* 2020;17.
- [9] Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)-a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inf* 2009;42:377–81.
- [10] Wong LE, Hawkins JE, Langness S, Murrell KL, Iris P, Sammann A. Where are all the patients? Addressing covid-19 fear to encourage sick patients to seek emergency care. *NEJM Catal Innov Care Deliv* 2020. Epub May 14, 2020, <https://catalyst.nejm.org/doi/full/10.1056/CAT.20.0193>.
- [11] Fisher JC, Tomita SS, Ginsburg HB, Gordon A, Walker D, Kuenzler KA. Increase in pediatric perforated appendicitis in the New York city metropolitan region at the epicenter of the COVID-19 outbreak. *Ann Surg* 2021;273(3):410–5. <https://doi.org/10.1097/SLA.0000000000004426>.
- [12] Friedman AA, Ahmed H, Gitlin JS, Palmer LS. Standardized education and parental awareness are lacking for testicular torsion. *J Pediatr Urol* 2016;12:166 e1–8.
- [13] Alyami FA, Modahi NH, Alharbi AM, Alkhelaif AA, Alhazmi H, Trbay MS, et al. Parents' awareness and knowledge of testicular torsion: a cross-sectional study. *Urol Ann* 2019;11:58–61.
- [14] Bayne CE, Villanueva J, Davis TD, Pohl HG, Rushton HG. Factors associated with delayed presentation and misdiagnosis of testicular torsion: a case-control study. *J Pediatr* 2017;186:200–4.
- [15] Preece J, Ching C, Yackey K, Jayanthi V, McLeod D, Alpert S, et al. Indicators and outcomes of transfer to tertiary pediatric hospitals for patients with testicular torsion. *J Pediatr Urol* 2017;13:388. e1-.e6.
- [16] Nelson CP, Kurtz MP, Logvinenko T, Venna A, McNamara ER. Timing and outcomes of testicular torsion during the COVID-19 crisis. *J Pediatr Urol* 2020 Dec;16(6):841.e1–5. <https://doi.org/10.1016/j.jpuro.2020.10.021>. Epub 2020 Oct 21. PMID: 33223456; PMCID: PMC7577251.
- [17] Littman AR, Janssen KM, Tong L, Wu H, Wang MD, Blum E, et al. Did COVID-19 affect time to presentation in the setting of pediatric testicular torsion? *Pediatr Emerg Care* 2021;37:123–5.
- [18] Yiee JH, Chang L, Kaplan A, Kwan L, Chung PJ, Litwin MS. Patterns of care in testicular torsion: influence of hospital transfer on testicular outcomes. *J Pediatr Urol* 2013;9:713–20.