Testicular Torsion: An Analysis of Rural Geography and Socioeconomic Status

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Abstract

Objectives Testicular torsion is a time-critical, organ-threatening diagnosis requiring prompt surgical intervention for successful salvage of the organ. In Australia, 28% of individuals live in rural and remote areas and face barriers to health care such as greater distance, lower socioeconomic status, (SES), and limited health infrastructure. We hypothesize that these barriers would delay intervention and access to surgical care, and lead to higher orchidectomy rates.

Objectives A 12-year retrospective audit was conducted at a large rural referral center in Australia, focusing on patients undergoing scrotal exploration for testicular torsion. Primary outcomes were orchidectomy rate, time to operation, and ultrasound (US) and their relationship with patient distance, SES, age, and peripheral hospital attendance. Data on SES for geographic postcodes was obtained from the Australian Government Socio-Economic Indexes for Areas 2016. Statistical analysis was performed using IBM SPSS Statistics software, and a P value < 0.05 was considered significant.

Results The study involved 107 patients, of whom 46% had left-sided pathology. The median age of the patients was 14 years. Median SES was in the 37% to 41% centile range, median distance from travelled was 62 kilometers, and median time to operation from triage was 194 minutes. Of the patients, 34 attended a peripheral hospital. No significant risk factors for orchidectomy were identified. US was used in 65% of cases, with torsion detected in 50% of those cases, and orchidectomy performed in 11 patients. US had a sensitivity of 86.1% and specificity of 52.9%.

Conclusion Despite significant differences in geographical distance, SES, age, and access to health care, patients in rural and remote areas of Australia experienced equivalent outcomes in testicular torsion management. Testicular torsion was safely managed at a central referral center using a peripheral hospital catchment in rural and remote areas of Australia, despite significant time delays due to greater distance or lower SES.

Introduction

Testicular torsion is a medical emergency, requiring prompt surgical intervention within 6 hours to salvage the affected organ[1]. International guidelines such as those from the European Association of Urology (EAU) and British Association of Urological Surgeons (BAUS) endorse urgent scrotal exploration as the mainstay of treatment[2,3].

In Australia, 7 million people (28% of the population) live in rural and remote areas, with higher health morbidity and mortality due to poor access and use of primary health care services compared with metropolitan areas[4]. Socioeconomic status (SES) plays a crucial role in determining health outcomes, and rural geography is a risk factor for low SES[5–7].

Key Words

Orchidectomy, testis, testicular torsion, rural health

Competing Interests

None declared.

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Abbreviations

IEO Index of Education and Occupation
IER Index of Economic Resources
IQR interquartile range
IRSAD Index of Relative Socio-economic Advantage and Disadvantage
IRSD Index of Relative Socio-economic Disadvantage
SEIFA Socio-Economic Indexes for Areas
SES socioeconomic status
US ultrasound

The Royal Australasian College of Surgeons (RACS) position statement on acute scrotal pain endorses the accreditation of general surgeons, pediatric surgeons, and urologists to manage and operate on suspected testicular torsion without transferring the patient[8]. However, rural and remote communities often lack adequate infrastructure or available surgeons, which can necessitate patient transfer and lead to potential delays to surgery and thus reduction in organ viability. The aim of this study was to examine the management of testicular torsion in rural areas and its relationship to distance, SES, or peripheral hospital attendance. Secondary outcomes included access to sonography and diagnostic accuracy in testicular torsion. We hypothesize that delays in surgical intervention due to increased distance from rural areas, hospital transfers, and reduced access to health care infrastructure would result in higher orchidectomy rates.

Method

A retrospective audit was performed at Dubbo Base Hospital, a large rural referral center in New South Wales, Australia, from October 2010 to February 2022. The hospital has a 24-hour on-call surgical service, access to operating theaters and anesthesia, and 24-hour on-call availability of ultrasonography and sonographers.

Electronic medical records from the Cerner application were used to identify patients of all ages who underwent scrotal exploration as a theater event. Baseline demographic information, residential postcode, time from triage to operation, age, laterality, ultrasonography usage, diagnosis at operation, and operative details were recorded. Patients with cryptorchidism, malignancy, and neonatal patients were excluded from the study.

Socioeconomic status

Socioeconomic status (SES) data was obtained from the publicly available Australian Bureau of Statistics: Socio-Economic Indexes for Areas 2016 (SEIFA)[9]. Four categories of SES were assessed: Index of Relative Socio-economic Disadvantage (IRSD), Index of Relative Socio-economic Advantage and Disadvantage (IRSAD), Index of Education and Occupation (IEO), and Index of Economic Resources (IER). SEIFA 2016 ranks postcodes according to variables of both advantage and disadvantage including income, education, employment, housing, disability, and access to infrastructure. Postcodes are assigned a national centile, with 1 indicating the lowest SES and 100 indicating the highest.

Peripheral hospital attendance and distance

The distance from the treating hospital was determined using Google Maps, considering road travel distance as all inter-hospital transfers were conducted by road transport. The distance was calculated from the center of the patient's residential postcode to represent the patient's local environmental resource and access to infrastructure[10].

Dubbo Base Hospital serves as a catchment for over 20 multipurpose health services or peripheral hospitals, all located outside the Dubbo Base Hospital's postcode. Peripheral hospitals did not have access to US but had a registered nurse or doctor available for clinical assessment. They also lacked an operating theater or surgeon. The time to operation was calculated from time of the first triage at the attending health center within the catchment to the start of operation. Rural geographical classification was determined using the Australian Government Modified Monash Model[11], which categorizes based on geographic remoteness and town size from MM1 (highest) to MM7 (lowest).

Primary outcome

Primary outcome was to determine the association between socioeconomic status, road distance, or peripheral hospital attendance and orchidectomy rate. Patients with intraoperative findings of testicular torsion were considered true positive. Orchidectomy was performed when intraoperative assessment deemed the testicle non-viable despite re-assessment after de-torsion and a minimum 15 minutes of warming. Orchidopexy was performed for viable testes according to the BURST-BAUS consensus guideline[2].

Secondary outcome

Secondary outcomes included an assessment of ultrasonography usage and its sensitivity, specificity, positive predictive value, negative predictive value, and accuracy in a rural setting. Ultrasonography was performed with color Doppler, and a positive finding was considered low or absent blood flow, with suspicious findings considered positive. Furthermore, an assessment was performed to determine whether SES, distance, or peripheral hospital attendance influenced use of ultrasonography.

Statistical analysis

IBM SPSS Statistics version 28[12] and Microsoft Excel were used for statistical analysis. The Shapiro-Wilk test was performed, along with data histogram, to determine normality. Independent t tests + chi-square tests were performed to compare baseline characteristics with normal distribution, and the non-parametric Mann-Whitney test was performed if the data distribution was not normal. Univariate regression and bivariate Pearson correlation were performed to compare outcomes of subgroups for dichotomous and continuous data, respectively. Multivariate regression was performed when significant results were found in the univariate regression to correct for potential confounding variables. A P value of < 0.05 was considered statistically significant.

Results

Patient characteristics

During the study period, 145 patients were identified, but only 107 were included in the analysis due to 38 patients having incomplete data or meeting the exclusion criteria. The most common reason for exclusion was cryptorchidism. Median age was 14 years, with 46% presenting with left-side symptoms (Table 1). All patients were from rural areas under the Modified Monash Model MM3-7. Torsion was present in 50% of cases, with left-sided torsion observed in 49%. Orchidectomy was performed in 12 patients, with median age of 13.5 years, and 83% of the cases were left sided. The degree of torsion was documented in 18 patients, and all 3 patients who underwent orchidectomy had rotation greater than 360 degrees. Of the 54 patients without torsion, 12 (22.2%) patients had torsion of the appendix testis and 10 (18.5%) had epididymitis. No cases of repeat scrotal exploration were identified. The median time to operation was 194 minutes from triage, but it was significantly longer (335 minutes) in patients who attended a peripheral health service. Upon arrival to emergency department of the operating hospital, median time between decision to operate and the actual operation was 32 minutes (interquartile range [IQR], 35 minutes). In patients with testicular torsion, no significant association was found between time from triage to operation and orchidectomy rate (odds ratio

TABLE 1.
Baseline characteristics

	All patients	Peripheral hospital attendance	Non-peripheral hospital attendance	*P* value
Patients	107	34	73	
Age, years, median (IQR)	14 (8)	13.5 (9)	14 (9)	0.237
Side of pathology				
Left, n (%)	49 (46)	21 (62)	28 (38)	0.024
Right, n (%)	58 (54)	13 (38)	45 (62)	
Side in torsion	53	20	33	
Left, n (%)	26 (49)	13 (65)	13 (39)	0.071
Right, n (%)	27 (51)	7 (35)	20 (61)	
Distance, km, median (IQR)	62 (60)	122 (121)	11 (74)	< 0.001
SES				
IRSD, percentile, median (IQR)	39 (27)	17 (32)	40 (11)	< 0.001
IRSAD, percentile, median (IQR)	37 (18)	22 (29)	38 (10)	< 0.001
IER, percentile, median (IQR)	38 (14)	29 (9)	38 (3)	<0.001
IEO, percentile, median (IQR)	41 (21)	21 (39.25)	41 (10.5)	0.044
Time to surgery from triage, minutes, median (IQR)	194 (220.5)	335 (191.25)	194 (223)	<0.001
Ultrasound performed, n (%)	70 (65)	23 (68)	47 (64)	0.741
Torsion present, n (%)	53 (50)	20 (59)	33 (45)	0.19
Orchidectomy, n (%)	12 (11)	3 (9)	9 (12)	0.593

IEO: Index of Education and Occupation; IER: Index of Economic Resources; IQR: interquartile range; IRSAD: Index of Relative Socio-economic Advantage and Disadvantage; IRSD: Index of Relative Socio-economic Disadvantage; km: kilometers; SES socioeconomic status.

TABLE 2.
Regression analysis for risk factors

	Orchidectomy			Ultrasound use			Time to operation		
	OR	95% CI	*P* value	OR	95% CI	*P* value	Pearson correlation coefficient	95% CI	*P* value
Distance	1.001	0.996–1.006	0.665	1.001	0.997–1.004	0.671	0.474	0.313–0.609	< 0.001
Age	1.008	0.95–1.07	0.787	1.022	0.977–1.067	0.341	0.033	-0.157–0.222	0.732
IRSD	0.994	0.955–1.033	0.748	0.991	0.964–1.018	0.5	-0.199	0.374–0.009	0.040
IRSAD	0.996	0.953–1.04	0.853	0.989	0.96–1.019	0.483	-0.169	-0.347–0.022	0.082
IER	1.006	0.971–1.043	0.743	0.993	0.97–1.017	0.584	-0.178	-0.356–0.012	0.067
IEO	1.012	0.957–1.07	0.676	0.981	0.944–1.019	0.32	-0.065	-0.251–0.127	0.508
Peripheral hospital attendance	0.688	0.174–2.722	0.594	1.157	0.488–2.743	0.741	1.004	1.001–1.006	0.002

CI: confidence interval; IEO: Index of Education and Occupation; IER: Index of Economic Resources; IRSAD: Index of Relative Socio-economic Advantage and Disadvantage; IRSD: Index of Relative Socio-economic Disadvantage; OR: odds ratio.

[OR], 0.999; $P = 0.584$). Age was not associated with increased orchidectomy rate, ultrasound use, or time to operation (Table 2).

Peripheral hospital attendance and distance

Of the total patients, 34 (31.8%) attended a peripheral hospital, with median age of 13.5 years. The majority of these patients (62%) had left-sided pathology, in contrast to those with non-peripheral hospital attendance, with 62% exhibiting right-sided pathology. However, no significant difference in laterality was identified ($P = 0.071$) in patients with diagnosis of torsion. The median distance from hospital was 122 kilometers (km) for patients attending a peripheral hospital, which was significantly further than that for non-peripheral hospital patients. Additionally, the time to operation was significantly longer for peripheral hospital attendees, at 335 minutes, compared to non-peripheral hospital attendees, at 194 minutes. There was no significant difference in torsion rate (59%) and orchidectomy rate (9%) between these 2 patient groups ($P = 0.19$ and $P = 0.593$, respectively). Increased distance from the hospital was not a significant risk factor for orchidectomy or ultrasonography use (Table 2). Similarly, peripheral hospital attendance was also not a significant risk factor for orchidectomy or ultrasonography use (Table 2). However, increased distance was significantly associated with increased time to operation ($P < 0.001$).

Socioeconomic status

The median IRSD was 39, IRSAD was 37, IEO was 38, and IEO was 41, with all patients falling within the lower 50% of Australia's national SES bracket. Patients who attended peripheral hospitals had a significantly lower median IRSD, IRSAD, IER, and IEO compared to those who presented directly—(IRSD 17 vs. 40, respectively), IRSAD (22 vs. 38, respectively), IER (29 vs. 38, respectively), and IEO (21 vs. 41, respectively). Of those patients who presented directly, 46 lived in the same suburb as the operating hospital. No significant association was identified between the 4 SES categories and orchidectomy rate or ultrasound use. IRSD, a measure of only SES disadvantage, correlated with increased time to operation ($P = 0.04$); however, IRSAD, IER, and IEO did not show a significant correlation.

Ultrasonography

Ultrasound was performed in 65% of patients preoperatively, with a sensitivity of 86.1%, specificity of 52.9%, positive predictive value of 66%, negative predictive value of 78.3%, and accuracy 70% (Table 3). Five patients had false-negative ultrasound results, and 16 patients had false-positive results. Of the 12 patients who underwent orchidectomy, 9 patients had preoperative ultrasonography, which correctly diagnosed the testicular torsion in all cases. Patients who underwent ultrasonography had significantly longer time to operation (349 minutes; standard deviation [SD], 348.8 minutes) compared to those without ultrasonography (176 minutes; SD, 131.5 minutes; $P = 0.005$), but there was no significant difference in the orchidectomy rate ($P = 0.464$).

TABLE 3.
Ultrasonography diagnosis

Sensitivity	86.1%
Specificity	52.9%
Positive predictive value	66%
Negative predictive value	78.3%
Accuracy	70%

Discussion

In Australia from 2020 to 2021, 1830 scrotal explorations were performed, as reported by the Australian Institute of Health and Welfare[13], an incidence of 1 per 50 000 in a population of 25.74 million in 2021. Australia has a population density of 3.3 people per square kilometer[14], primarily due to population sparsity in rural and remote areas, where 7 million (28%) of Australians live. The combination of geographic isolation and a rare pathology exacerbate the time-critical challenge of managing testicular torsion. The limited accessibility to healthcare infrastructure due to geographic distance acts as a major obstacle to achieving positive outcomes.

Testicular torsion is a medical emergency that necessitates prompt surgical intervention, with the duration of symptoms being the primary predictor in the success of salvage procedures[15]. We hypothesized that barriers to healthcare such as geographical distance, peripheral hospital attendance, and low SES could delay intervention and increase orchidectomy rates. Prompt surgical intervention plays a crucial role in reducing morbidity and mortality in emergency surgery[16], with patients residing in rural areas showing an association with equivocal or worse outcomes[17], particularly among transferred patients. Geographical remoteness is significantly correlated with lower SES, and SES itself is associated with worse outcomes in emergency surgery even when corrected for remoteness[18], suggesting that SES is the predominant risk factor for morbidity. In Australia, some patients who reside in rural or remote communities will elect to have surgical care closer to their homes despite being informed about the higher risks for morbidity and mortality[19]. As a result, the core curriculum for both urology and general surgery trainees in Australia includes the competence to assess and perform scrotal explorations for testicular torsion at a patient's initial presentation, regardless of their geographical location, without the need for transfer[8].

Limited literature exists on the impact of geographical location on testicular torsion outcomes from a distance and SES perspective, and the study findings are heterogeneous. A national study in Korea comparing metropolitan and rural provinces demonstrated no significant difference in incidence or orchidectomy rates based on geographic region or SES[20]. The authors Choi et al. hypothesized that this is due to the ease of accessibility of public healthcare services in a relatively small country of 100 210 square kilometers. However, this contrasts the findings of the current study, conducted at a rural referral center with a catchment of 250 000 square kilometers. A study in the United States conducted by Overholt et al.[21] demonstrated higher orchidectomy rates in patients who required transfer from peripheral health services, but did not find a significant correlation with distance or time delay. The authors acknowledged their study's small sample size at only 23 patients, rendering the study underpowered and the findings nonsignificant. In contrast, our study, with a larger sample size (n = 107) and despite having patients who were geographically more distant (median 62 km vs. mean 38.3 km), did not find a significantly increased orchidectomy rate despite significantly longer time to operation. The Australian health care system, publicly funded by Medicare, relies on healthcare networks in rural areas, involving a catchment of multipurpose health services connected to a large rural referral hospital. This system ensures access to a 24-hour virtual doctor service at peripheral sites and facilitates inter-hospital transfers to a rural referral hospital where a surgeon is available on call 24 hours a day. This timely access to clinical assessment allows for prompt review and escalation, thereby alleviating disparities in rural and remote health care, in both surgical and medical care, to ensure patients from lower socioeconomic backgrounds receive optimal care. These initiatives by the Australian Government are part of the Stronger Rural Health Strategy[22], which aims to offset disadvantages related to access to and delivery of health care in rural and remote areas. This may explain why significant findings were found only in the SES category of IRSD, which measures variables related only to disadvantage, while IRSAD, IEO, and IER, which measure variables of advantage, such as higher education level, higher income brackets, and certain occupations, could mitigate or compensate for disadvantage.

Ultrasonography has seen increasing use for the assessment of possible testicular torsion, despite guideline recommendations that testicular torsion is a clinical diagnosis[8]. The diagnostic ability of sonography for testicular torsion in adults has shown a sensitivity of 86% and specificity 95%[23]. These results are aligned with our study findings, with a similar sensitivity but a much lower specificity. The low specificity could be due to a high false-positive rate, as "suspicious" findings were coded as positive, leading to scrotal exploration in all cases. There are numerous decision-making tools available, such as the TWIST score in all ages[24,25], reporting a high sensitivity of 98.4% to 100% in low-risk patients and safely ruling out testicular torsion prior to

ultrasonography. Thus, we recommend reserving sonography for patients falling into the medium-risk groups as an adjunct to support clinician suspicion, and we suggest incorporating other scoring systems as decision-making adjuncts. It is widely advocated in the literature that ultrasound should not delay scrotal exploration in high-risk patients due to increased rate of non-viable testes due to in-hospital time delays[26]. However, in our study, we found much lower orchidectomy rates overall compared to the literature, despite there being significant in-hospital delays[26], indicating a potential underpowering to assess the relationship between ultrasonography and orchidectomy. Therefore, we agree with contemporary guidelines and advocate for scrotal exploration based on clinical findings, as ultrasonography nearly doubled the time to definitive management in this study.

A limitation of this study is the inability to analyze the correlation between orchidectomy rates and symptom onset or degree of torsion due to incomplete and heterogeneous documentation, prohibiting accurate data collection. The literature establishes that symptom onset followed by torsion rotation is the predominant established risk factor[27,28] and when symptom onset is < 24 hours, hospital transfer has been shown to significantly increase orchidectomy rates[29]. However, in this study, we found no significant increase in orchidectomy rates associated with in-hospital delay to theaters, likely because the majority of patients underwent surgery within 4 hours of presentation. No manual de-torsion was performed and thus its role could not be assessed. Furthermore, the absence of network guidelines or protocols resulted in inconsistency in clinician decision-making, with a mix of registered nurses, general practitioners, general surgeons, and urologists making assessments and determining the need for transfer and surgery. In particular, this could explain the high rate of ultrasonography usage, but no significant differences in ultrasonography use were identified between peripheral and non-peripheral hospitals. The orchidectomy rate in this study for patients with torsion was 22.6%, which is lower than the rates described in the literature, which can rise up to 39%[27]. This difference suggests that the analysis may have been underpowered to appropriately assess orchidectomy and its relationship with the variables described. We recommend future multicenter studies with sufficient samples sizes to further examine the relationships described in this study. Due to incomplete or unavailable data, follow-up was not assessed, predominantly due to barriers in rural health care, including limited patient access to health care follow-up or incomplete assessments performed by non-surgical healthcare providers at peripheral health sites.

Conclusion

In conclusion, our findings indicate that for patients residing in rural-remote areas of Australia, geographical distance, SES, age, and peripheral hospital attendance were not significant risk factors for orchidectomy rate. Despite significant time delays associated with peripheral hospital attendance, geographic remoteness, and low SES, we suggest that testicular torsion can be managed safely in rural health care settings, particularly within a rural referral center with a peripheral hospital catchment. Future multicenter, prospective studies examining symptom onset and clinical decision-making rules, such as TWIST score, should be performed in rural health care settings to assess the diagnostic accuracy and the role and safety of ultrasonography in the management of this organ-threatening condition.

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The research protocol (PID01054/ETH00931/STE01878) was approved by the Greater Western Human Ethics Research Committee as a negligible/low-risk project. The data were retrospectively collected and de-identified, eliminating the need for informed consent from each patient. This study did not involve any trials or animal experiments. The authors would like to disclose that they have not received any grant support and they declare no conflicts of interest. All the authors have reviewed and agree upon the content of the manuscript. The manuscript has not been previously published and it is not under consideration elsewhere.

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