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A STUDY OF NON-PATIENT FACTORS CONTRIBUTING TO RUPTURED APPENDICITIS IN SWAT.

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ABSTRACT

Background: Ruptured appendicitis is still prevalent. Adult rates of ruptured appendicitis vary from 13.2 to 41.9 percent in bigger hospitals, despite controlling for individual factors like age, sex, co morbidity and socioeconomic status. This suggests an effect of hospital organization. Surgeons report that appendicectomies may be delayed because of lack of access to operating theater.
Methods: Combining interviews with hospital personnel and information from the medical record, for year 2011, a cross sectional study was conducted on 4305 patients. Four hospitals were included in the study. The diagnostic information was recorded to ensure inter hospital validity. Results: Hospital with high activity and volume of patients, but without an operation theatre designated for urgent surgery, was associated with a significant higher rate of peritonitis (P=< 0.050). Time to surgery after departure from Accident and Emergency department, was very long in hospital having no operating theater for urgent surgery particularly elderly patients.
Conclusion: Hospital characteristics in unfavorable combinations influence the course of time-dependent disease such as appendicitis. Difficulties in gaining access to operating theater, even for urgent operations, have emerged. Delays in treatment must be addressed when planning healthcare reforms.
Keywords: Perforated appendicitis, peritonitis, urgent surgery

INTRODUCTION

Appendicitis is a common cause of acute abdominal pain[1] and the most common intra abdominal condition requiring emergency surgery, with a lifetime risk of 6-8 percent[2,3]. Although the introduction of laparoscopic surgery has dramatically changed the field of surgery[4], but since its introduction by Mc Burney in 1894, open appendicectomy has been the treatment of choice for acute appendicitis[5]. Its aetiology includes obstruction of its lumen by in spissated stool, foreign bodies and intestinal parasites. Non obstructive causes include endometriosis, leukaemia, emotional stress, mucosal and submucosal inflammation secondary to bacterial invasion of lymphoid tissue of the appendix, trauma, low fiber diet, excessive consumption of potatoes[6], prolonged use of non steroidal anti inflammatory drugs in the elderly group[7] and familial tendency[8]. Characteristic presentation of acute appendicitis includes periumbilical pain, nausea and right lower quadrant pain, followed by vomiting, fever (38^{0}C) and tachycardia pain, followed by vomiting, fever (38^{0}C) and tachycardia. This presentation is only seen in half of the adults, however and even less commonly in children[9,10]. Patient is often flushed, with a dry tongue and an associated fetor oris. There is localized tenderness over Mc Burney's point, guarding, muscular rigidity and rebound tenderness[11]. Its investigations include white cell count, plain abdominal x ray, ultrasound, CT scan, aspiration cytology of peritoneal fluid, urinalysis, laparoscopy[8] and pregnancy test in a woman of childbearing age[12]. Though novel inflammatory markers including interleukin6 has been assessed with little additional merit, the most commonly used are total white cell count, neutrophil count and C-reactive protein[13]. Diagnosis of acute appendicitis remains a problem in pediatric

surgery[14], a delay in the diagnosis of acute appendicitis in children is associated with increased risk of perforation (upto 62 percent) and further complications[15]. Similarly the diagnosis of acute appendicitis in morbidly obese patients pose a problem and the diagnosis is sometimes made at postmortem[16]. Appendicectomy specimens removed from patients with suspected acute appendicitis often appear normal but histological analysis of these cases may reveal a more sinister underlying pathology[17].

Despite antibiotics and improved perioperative care[18-21], patients with perforated appendicitis have much higher rates of death[22-24], morbidity and complications[20,25-28] and longer hospital stay[20,25,29-31] and higher associated personal and healthcare costs [20,25] than those without peritonitis. Long duration of symptoms until surgery as a result of delayed consultation by the patient[20,28,29,32-35], delayed treatment by the physician[18,20,22,32-38], or both[19,25,26,31,39-42] are an important factor leading to perforation of the appendix. Rates of perforated appendicitis are an indicator of access to and quality of healthcare[22,36,43-47]. Also demonstrated by Tousignant *et al*[48] important interhospital variation in the rates of perforated appendicitis in the Montreal area for adults aged 18 years or more ranging from 13.2 to 41.9 percent. As these ruptured rates were adjusted for age, sex, co-morbidity and socioeconomic status, it is possible that institutional elements within the hospitals themselves contributed to the variations in outcomes. Other authors have shown that healthcare characteristics are associated with perforated appendicitis[20,24,28,43-47].

The city of Swat is the largest urban area of Malakand Division, with a population of 1 million. The catchment area of its hospitals include about 4million inhabitants spreading over 7 districts. Government hospital and its medical services are universally accessible and funded by ministry of health of the province. The contributing private hospitals charge from patients for their expenses and have an easy and early access to emergency operation theater and had separate designated operation theater for urgent cases. The objectives of this study were to determine whether longer hospital times (delays) to appendicectomy contributed to inter hospital variation and whether hospital organizational characteristics could explain the rates of appendicitis with peritonitis.

PATIENTS AND METHODS

Four hospitals were selected, who performed at least more than 100 appendicectomies per year. The hospitals included Saidu Teaching hospital, with two surgical units A and B, Shah Surgical Hospital, Shifa Medical Center and Swat Medical Complex. The Saidu Teaching is a public funded tertiary care hospital, while the other three are private hospitals. The tertiary care hospital has a common operation theater with 5 tables, recovery room, procedure room and a two bedded surgical ICU.

The tertiary care hospital has a common operation theater with 5 tables, recovery room, procedure room and a two bedded surgical ICU. The two surgical units and ENT department share the operation theater. Therefore it has an elective list daily (Monday-Saturday) and 7 days a week emergency for general surgery and ENT. There is no separate operation theater for emergencies and emergency cases coming after midnight to wards, from Accident and Emergency (A&E) department have to wait until 2PM till all elective cases have cleared. On the contrary the three private hospitals have easy access to operation theaters, 24 hours a day and on weekends, with a minimum hospital delay. Hospital characteristics were obtained by interviews with the hospital administrators, heads of anesthesiology, surgery and A&E, A total of 16 interviews were recorded. The institutional ethics committee approved this study.

Inclusion and Exclusion criteria:

Patients who had appendicectomy for appendicitis were selected from the above hospitals. Exclusion criteria were interval appendicectomy, no surgery, a diagnosis of chronic appendicitis, unqualified appendicitis, absence of disease of appendicitis, other diagnosis in appendicitis like crohn's disease, tuberculosis, carcinoid tumor, carcinoma, worm etc, diagnosis unrelated to appendix, incidental appendicectomy and children of 10 years and below age[49], due to higher peritonitis

rates, difficulties in diagnosis[50-52] and potentially different process of care in pediatric centers.

Variables

The main outcome was perforated appendicitis, according to the final diagnosis. The term, perforated appendix was used to describe appendicitis with perforation, rupture or with abscess formation. Gangrenous appendicitis was not considered as peritonitis in this study. Time was divided into prehospital delay (from the start of symptoms to arrival at hospital), time spent in the A&E department and post A&E delay (interval between discharge from A&E and surgery). The prehospital delay had to be approximated for many patients because the exact hour at which symptoms commenced was often not recorded in the hospital notes (74.8 percent). A review of the literature has shown that prehospital delays are an important predictor of perforated appendicitis and it was decided that they should be included in the analyses. A systematic approach was used to provide the missing data, as described below.

Moment of the day (for example morning) was available for an additional 30.5 percent of patients. To establish their prehospital delay or fixed hour was attributed to each moment of the day. If the time of onset of symptoms was not specified, but duration was provided, the corresponding time was allotted. If no time was specified but the date was given, the time estimated using noon as the start of the symptoms or midnight if the patient presented to A& E before noon (54 patients). Other time values were collected from the patient records.

A configurational approach[53] was used with organizational characteristics because of co-linearity among them. Nine characteristics that reflect competition for the resources available to a patient with suspected appendicitis, and that could influence timely access to the operating theater, were used. Demand on available resources consisted of the following variables: presence of obstetrics in the hospital, presence of neurosurgery and/or cardiac surgery and/or trauma in the hospital (complex surgery), total annual volume of patients admitted to the hospital, annual volume of day surgery, annual volume of surgery excluding day surgical procedures and annual volume of elective surgery with admission on the same day. Available resources variables were, anesthesiologist on call in hospital or at home, operating room designated for emergencies and availability of ultrasonography and computed tomography (CT) at all times or on weekdays only.

The term complex surgery is used to describe specialties that usually pose an important burden on the operating suite: long operations, many urgent cases, frequent urgent reoperations, many staff required, advance technology, etc. These specialties tend to place considerable demand on operating theater resources, so patients with diseases such as appendicitis must wait for an operation theater to become available. The percentage of appendicectomies carried out during the evening was calculated on the basis of start of surgery, anesthesiology or arrival at the operating theater. Consultation with any other doctor in the week preceding admission and moment of surgery were linked together. Patient age sex and whether they had preoperative ultrasonography or CT, were obtained from the records. Distance from home to hospital and the mode of transport (as not all patients arrive by ambulance) were taken into account. Socioeconomic status and severity of illness recorded. Former was assessed using pampalon material deprivation index[54], where 100 represent low and 0 denotes high socioeconomic status. The later was graded from minor to extreme based on all patient refined diagnosis-related groups[55] (APR-DRG), was obtained from MED-ECHO.

Statistical Analysis

Of 4830 patients, 525 were excluded (Table 1), leaving 4305 patients from four hospitals, for analysis. Of these 1120(26.01percent) had perforated appendicitis and 3185(73.98 percent) appendicitis.

Table 1 Excluded patients.

Exclusion criteria	No. of patients
Age	145
Appendicitis without surgery	95
Elective/ interval appendicectomy.	35
Chronic appendicitis	95
Unqualified appendicitis	25
Incidental appendicectomy	65
Absence of disease of appendix	50
Diagnosis unrelated to appendix	10
Other diseases of appendix	5
Total	**525**

Baseline characteristics of the patients are shown in Table 2.

Total time (days)*	2.84(7.54)(1.54)
Prehospital time (days)*	2.16(6.93)(1.00)
Time in A+E (Days)*	0.47(0.33)(0.38)
Post A+E time (Days)*	0.23(0.55)(0.03)
Age (years)*	37.73(16.48)(34.0)
Home-hospital distance(km)*	9.65(16.98)(4.60)
Socioeconomic status*	44.2(32.05)(42.00)
Peritonitis!	
Yes	1120(26.0)
No	3185(74.0)
Previous medical consultation	
Yes	990(23.0)
No	3310(77.0)
Preoperative abdominal US	
Yes	2535(59.4)
No	1735(40.6)
Preoperative abdominal CT	
Yes	600(14.1)
No	3650(85.9)
Preoperative abdominal US and CT	
Yes	380(8.9)
No	3875(91.1)
Sex	
Male	2510(58.3)
Female	1795(41.7)
APR-DRG severity of illness	
1(minor)	3445(80.0)
2(moderate)	690(16.0)
3(major)	155(3.6)
4(extreme)	15(0.4)
Contributing hospitals	
1. Saidu Teaching Hospital, Swat. Pakistan	2721(63.2)
2. Shah Surgical Hospital, Swat. Pakistan	563(13.0)
3. Shifa Medical Centre, Swat. Pakistan	520(12.0)
4. Swat Medical Complex, Swat. Pakistan	501(11.7)

They are typical of what might be expected in a population of patients with appendicitis, with a majority of males and little co-morbidity[20, 22,24,26,50]. The data from four hospitals were separately analyzed. They all had high volume of patients with many competing activities. All except the teaching hospital had separate designated operation theater for urgent cases like appendicitis with a 24 hours easy access of urgent cases.

Table 3 shows the characteristics of patients and hospitals. Patient characteristics did not vary importantly between the hospitals but rates of ruptured appendicitis were high in teaching hospital.

Table 3
Characteristics of participating hospitals

Name of Hospital	1. Saidu	2. Shah	3. Shifa	4. Swat
Mean Age(years)	38.5	37.7	38.1	35.0
Female patients (%)	41.6	44.0	41.6	41.1
Socioeconomic status(median)	34.0	36.5	35.0	67.5
Peritonitis (%)	34.5	9.4	13.0	12.0
APR-DRG grade1 (%)	82.7	77.0	77.8	81.4
Previous medical consultation (%)*	22.3	25.4	23.1	24.2
Preoperative abdominal US	48.0	64.6	49.9	54.3
Preoperative abdominal CT	18.2	16.6	12.5	7.3
Anesthetist on call in hospital	49.8	41.2	32.0	28.4
Obstetrics on call in hospital	100.0	0	47.8	50.6
Complex surgical specialties	79.7	50.3	46.1	0
Operating theatre for emergencies	0	100	100	100
24-h imaging	100	100	100	100
Prehospital time (days)				
Mean	2.43	2.14	2.29	2.88
Median	1.00	1.00	1.00	1.00
Time in A+E (h)				
Mean(h)	10.08	10.56	12.96	10.80
Median(h)	8.64	8.64	10.56	9.12
Maximum days	1.63	2.15	2.00	1.98
Post A+E time				
Mean(h)	5.28	7.20	5.32	2.88
Median(h)	1.20	0.96	0.96	0.48
Maximum(days)	3.33	6.01	4.35	3.27

The results of multivariate logistics regression are shown in Table 4. Odds ratios (OR) were controlled for all variables present in the table and clustering of patients by hospitals. The clustering was weak, age, prehospital time, previous consultation and clinical severity were patient characteristics significantly associated with rupture. Hospital factors associated with perforation were Saidu Teaching Hospital and lack of separate operation theater for urgent surgery over weekdays.

Table 5 shows hospital times in relation to the preoperative diagnosis. The relationship between age, post A&E delay and perforation is presented in further detail in Table 6. The time surgery during weekdays and at weekends in relation to rates of perforated appendicitis is shown in Table 7.

Table 4 Multivariate analyses

	Odds ratio	*P*
Prehospital time*	1.05(1.01,1.08)	0.020
Time in A+E	0.88(0.49, 1.56)	0.662
Post A+E time!	1.20(0.78, 1.84)	0.415
Previous medical consultation	1.61(1.26, 2.05)	<0.001
Age	1.32(1.18, 1.47)	<0.001
Severity of illness	2.74(1.86, 4.05)	<0.001
Preoperative USS	0.57(0.34, 0.98)	0.043
Preoperative CT	0.51(0.24,1.09)	0.084
Preoperative USS and CT	4.04(1.22,13.37)	0.022
Hospital model(*versus* model 1)		
2	0.45(0.23,0.85)	0.014
3	0.57(0.34,0.97)	0.016
4	0.57(0.37,0.90)	0.038
Time(versus weekdays#)		
Weekend or holiday	0.59(0.33,1.06)	0.079
2.00pm to 23.59pm	0.79(0.47,1.33)	0.370
12.00 am to 5.59am	0.99(0.63,1.57)	0.974

Table 5

Preoperative diagnosis and hospital times.

	Preoperative diagnosis*		
	Appendicitis	Perforated or abscessed appendicitis	Other
No of patients	3585	475	170
Time in A+E(h)	11.18(9.04)	12.11(10.48)	10.56(8.89)
Post A+E time(h)	5.54(0.83)	5.70(0.75)	5.56(1.38)

Table 6.

Delay to Surgery and rates of peritonitis, in relation to age.

Age group(years)	Peritonitis (%)	Prehospital time(days)*	Time in A+E(h)*	Post A+E time(h)*
11-17	18.0	1.68(1.00)	11.50(9.75)	3.08(0.74)
18-29	14.5	2.20(1.00)	10.62(8.63)	3.14(0.67)
30-39	22.4	2.00(1.00)	10.84(9.10)	3.14(0.74)
40-49	28.7	1.46(1.00)	11.25(8.85)	8.24(1.35)
50-59	39.8	2.27(1.00)	11.96(9.18)	5.88(1.68)
e60	52.9	3.19(1.00)	13.15(9.64)	12.20(1.71)

Table 7

Post hoc analyses examining timing of surgery in relation to perforated appendicitis rates.

Hospital	Observation	Weekday*	Weekend or holiday
Saidu teaching Hospital, Swat	Perforated appendicitis (%)	38.8	27.5
	Mean post A+E time(days)		
	Appendicitis	0.22	0.28
	Perforated appendicitis	0.65	0.15
Shah Surgical Hospital, Swat	Perforated appendicitis (%)	18.2	15.8
	Mean post A+E time(days)		
	Appendicitis	0.29	0.17
	Perforated appendicitis	0.32	0.16
Shifa Medical Centre, Swat	Perforated appendicitis (%)	33.7	21.3
	Mean post A+E time(days)		
	Appendicitis	0.17	0.10
	Perforated appendicitis	0.56	0.10
Swat Medical Complex, Swat	Perforated appendicitis (%)	28.8	2.9
	Mean post A+E time(days)		
	Appendicitis	0.11	0.03
	Perforated appendicitis	0.54	0.01
All patients	Perforated appendicitis (%)	30.3	18.1

Values in paracentheses are percentages unless indicated otherwise; *values are mean (s.d.) (median). Socioeconomic status rated from 0 (high) to 100 (low)[54]. International classification of disease revision. In the seven days before admission to hospital. A+E Accident and emergency department; US Ultrasonography; CT Computerized tomography; APR-DRG all patient refined-diagnosis related group. Total may not equal to 4305 as because of missing information in the notes.

* In the 7 days before admission to hospital. APR-DRG all patient refined-diagnosis related group; US Ultrasonography; CT Computerized tomography; A+E Accident and emergency department.

Values in paracentheses are 95 per cent confidence intervals. Adjusted for variables in table and also for home-hospital distance(more or less than 5km), socioeconomic status(difference of 25 points on a 100-point scale), proportion of appendicectomies performed between 2.00pm and 6.00am next morning and moment of consultation in the Accident and emergency department(A+E)(evening or night *versus* daytime). These variables were not significant at a statistical level of 0.005. Also adjusted for hospital clustering using generalized linear modeling. Sex was not kept in the final model because it did not contribute any information. *One-day difference; above or below 75th percentile value of 15.1h; above or below 75th percentile value of 4.3h; §10-year difference; 1 unit difference on all patient refined diagnosis-related group clinical severity index; # Monday to Saturday 2.00pm and 6.00am, except holidays. US, Ultrasonography; CT, Computerized tomography.

Values are mean(median). *As written by the attending surgeon in the operative note(medical record). Total does not equal4305 because of missing information on preoperative diagnosis. A+E, accident and emergency department.

*Values are mean (median). A+E, accident and emergency department.

*From 8.00am to 2.00pm (time from 6.00am to 8.00am was not accounted for, as there was no appendicectomy performed during this time) Monday to Saturday, except holidays. International classification of diseases revision 9 codes were 540.9 and 543.9 for appendicitis and 540.0 and 540.1 for perforated appendicitis. A+E, accident and emergency department.

DISCUSSION

The main finding of the study is the significant association between hospital organization with high activity and without an operation theater for emergencies and perforated appendicitis, despite controlling for individual factors and delays. Usual patient factors associated with perforated appendicitis were also significant, namely prehospital delay.

A&E and post A&E delays were not significant in the multivariate analyses. This is surprising as delays are considered to be intermediate events between appendicitis and perforation. There were no differences in A&E delays between patients with suspected appendicitis and those with perforated appendicitis (Table 5).

Inspite of the lack of an association between A&E delays and perforation, the length of these delays raises concern. Patients with suspected appendicitis should logically undergo surgery with a shorter delay than those with uncomplicated appendicitis[56]. In addition appendicectomy with in 6 hours is recommended to prevent rupture[25,32]. The main delay in this study was 16.8hours, from arrival in A&E to surgery. This is longer than a Canadian study by Temple et al which is 7hours and also another study conducted in the periphery of Montreal[29] (12.1 hours) in adults. The non-significance of post A&E delays in the present models may be due to confounding between age and post A&E delay (Table 6). Older patients waited for upto three times longer than younger ones, with corresponding increases in rates of peritonitis (Table 6). Delays relating to stabilization can account for only 9.2 percent of peritonitis aged over 50 years, because only 95 percent of them had a severity of illness grade 3 or 4. Such delays might be related to the fact that appendicitis is more difficult to diagnose in this age group [41,52,57] and is often not looked for because appendicitis is typically depicted as disease of youth. Surgeons are also more conservative towards older patients and ensure maximum preoperative preparation.

The lack of significance could also be related to confounding between post A&E delays and organizational models. Such confounding became apparent in a post hoc analysis that examined the relationship between presentation at weekends and perforation. In multivariate analyses there were fewer cases of perforated appendicitis on weekends and holidays than on weekdays and result almost reached significance (Table7). Post A&E delays were much longer on weekdays for patients with perforation in the hospital without an operation theatre for emergency cases. So a patient presenting to A&E after midnight will wait till 8am before shifted to concerned unit (AorB) or out patient department (OPD). After admission this patient will have to wait until 2pm, when all emergencies will be operated. This is to avoid interference with elective operations in the morning shift. The patients with appendicitis may wait another 6-8 hours if other emergency cases like, perforated viscus, obstructions, scrotal tortions, fire arm injuries, stab wounds and patients of road traffic accidents, are to be operated before them. Most of the time appendicitis cases may be left till next morning, so as completing 24 hours in hospital and so on. This was the case in teaching hospital, but not in the other 3 hospitals where there was easy access to the operation theatre, designated for such cases and competition by other emergency cases was minimal. Also other major emergencies like firearm injuries and road traffic accidents were only admitted and operated in the teaching hospital.

At weekends the post A&E delay was the same or shorter for patients with peritonitis. These results suggest that there were problems with access to the operating theater and concur with the results shown in Table 4, suggesting an important effect of operating theater dedicated to urgent surgery.

Two Canadian studies[58-59] and a prospective British

study carried out in London demonstrated similar results following healthcare reconfiguration. One third of urgent operations were moved to the evenings or weekends, mostly because operating theatres were being used for non-urgent procedures[60].

Previous consultation with a physician was strongly associated with peritonitis, as noted previously[33]. We do not have GPs and trained family physicians that can identify and refer surgical patients in time. Prehospital time and previous consultation were correlated and both were associated with peritonitis. This could be a proxy for difficult diagnosis, but further explanatory factors should be sought.

The study has several limitations because of its cross-sectional design and retrospective access to the medical records. In particular, information on difficulty of diagnosis, whether patient or organization related, was not available. This might explain the remaining variation in peritonitis rates between hospitals and the inconsistencies in duration of symptoms. The presence of co-morbidity could not account for the severity and importance of co-existing disease. For this reason, severity of illness was included in hospital data, resulting in a better explanation, although this variable represents all that went on during the hospital stay and not necessarily the initial condition of the patients.
There are some precision issues with time variables. This is of particular concern for prehospital delays. About 5 percent of times written in the files required correction because of gross error, especially around midnight and year change. Other had to be estimated because the available information was imprecise. These errors or missing values might have affected the association between time and perforation. However it has been demonstrated previously that time and peritonitis have a complex relationship that is not necessarily linear[22]. Finally some hospitals performing fewer than 100 appendicectomies annually like New modern, Dilaram, New Cenna and Aizaz Surgical centers in Swat were excluded.

This study has several strengths. Many of the results reported derive from comparison of hospitals. The validity of this comparison is largely a function of the reliability of the diagnosis, which was secured by one person collecting data and giving the final diagnosis for all hospitals. Hospital and clinical information were included in the analyses to diminish bias and cross-reference the information.

Furthermore clustering of the patients by hospital was taken into account and patients were selected from hospitals that performed most appendicectomies.

There is no single solution to reducing perforation rates from acute appendicitis, however, because the problem has at least three components: timely consultation by the patient, timely and accurate diagnosis by physician, and timely appendicectomy.

Antibiotics protect against severe peritonitis but not against perforation and its sequelae, which remain important[18-21]. Measures to improve access to the operating theatre are still needed if the burden of high rates of peritonitis is to be reduced. Deeper understanding of organizational factors implicated in delayed treatment of time-dependent disease is needed to help hospitals that are facing reorganization problems, make the best of resources they have.

CONCLUSION

Time dependent disease like acute Appendicitis need to be operated on priority basis in order to reduce the chances of perforation that result from this delay. While planning operating theater in a new hospital, provision for emergency operating theater and own staff shall be kept in mind. Those hospitals that do not have this facility should make this facility available. The Saidu Teaching hospital has now this facility available.

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