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The association of body mass index and perforation of the appendix in Puerto Rican children

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Childhood obesity is a leading public health concern that disproportionately affects low income and minority children. It is currently a rising epidemic affecting many countries in the world, including Puerto Rico. Prevention programs on the Island have included the distribution of $7.8 million dollars among the various municipalities for the development of the program "Get moving Puerto Rico". Unfortunately, the incidence of obesity and overweight continues to increase at alarming rates and it is up to 40% among the pediatric population. [1-3].

The obesity epidemic is a threatening crisis that requires global efforts to attend this multifactorial problem. The medical costs of pediatric obesity are on the rise and without effective intervention; these costs could be catastrophic [4]. Obesity and overweight involve significant risks to physical and emotional health in children, and it has already been demonstrated that higher health services are required for this population. Early screening for hyperlipidemias, cardiac disease, sleep apnea, diabetes, orthopedic related problems and endocrinologic disturbances is recommended at any age upon suspicion by the primary physician and/or subspecialist or when the BMI is above the 85th percentile [5].

Clinical challenges such as increased size and decreased mobility, increased fat in chest and abdominal wall, and alterations in physiologic responses to injury, stress and illness have been well described in this population [5, 6]. In Puerto Rico, clinicians dealing with abdominal emergencies such as appendicitis encounter on a daily basis an increased number of pediatric patients with overweight and obesity. This had lead to a more aggressive approach of combining clinical examination with imaging studies such as ultrasound and computed tomography in order to make a diagnosis, which could still be difficult to obtain [7,8].

Although no systematic data is available in Puerto Rico, the local Department of Health statistics report suggests that appendicitis is the most common surgical emergency on the Island [9]. The primary adverse outcome of this disease is appendiceal perforation. After 36-48 hrs of symptoms, the risk of appendiceal perforation is high, thus leading to a large number of complications, which have been described to range from 39-58% [10, 11]. Thus, it remains critically important to improve the speed and accuracy of the diagnosis of acute appendicitis to minimize the number of cases that lead to rupture. In the United States, pre-hospitalization factors such as access to care, quality of care, race, insurance, and patient education have been associated with higher rates of appendiceal perforation [12-16]. For example, minority children in the United States (Blacks, Hispanics and Asians) are 24-38% more likely than White to experience appendiceal rupture and its complications; children aged between 4-8 yrs have twice the odds of appendiceal ruptured when compared to older

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children; and having public or no insurance increases the odds of appendiceal rupture by 10%. Other factors associated with increased odds of appendiceal rupture include admission source other than Emergency Room and being treated at large volume hospitals[13].

The Department of Health in Puerto Rico does not have any information on appendicitis and ruptured rates since 1996. There are no studies on the prevalence and influencing factors leading to perforation. However, preliminary unpublished data from a private Children's Hospital in San Juan for the year 2008 showed alarming perforation rates of 59% in children, with 62% of these being overweight or obese.

In this study, we evaluated the clinical and demographic characteristics of children with appendicitis aged 2 to 19 years at two major children's hospitals in the San Juan metro area. Specifically, we examined the association of Body Mass Index as an independent variable for appendiceal perforation. Other variables such as gender, age, insurance, onset of symptoms and type of hospital were also explored to assess their role in appendiceal perforation. We suspect that these variables will be relevant in our pediatric cohort with appendicitis as they have been significantly associated to appendiceal perforation in the United States population.

Methods

Study population

Data in this study were obtained from the medical record offices at the San Jorge Children's Hospital and the University Pediatric Hospital, both in San Juan, Puerto Rico. The San Jorge Children's Hospital is a for-profit free standing pediatric hospital and the University Pediatric Hospital is a not-for-profit government pediatric hospital. Information on 178 medical records on children with appendicitis aged 2 to 19 years was abstracted. All patients were discharged between June 1, 2002, and December 30, 2009. The criterion for inclusion was any child aged 2 to 19 years with a principal diagnosis of appendicitis and a principal International Statistical Classification of Diseases, 10th revision (ICD-9) diagnosis codes of 540.0, 540.1, 540.9, 541 and 542. One child who resided abroad was excluded. Five patients with missing clinical data were also excluded. Children with appendicitis who were treated initially with non operative management and later followed by interval appendectomy were excluded for the secondary analysis of outcomes and complications.

This study was approved by the Institutional Review Board of the San Jorge Children's Hospital and the University of Puerto Rico Medical Sciences campus, San Juan, Puerto Rico (IRB# 2770110).

Outcome measures

Patients were stratified into 3 groups: 64 patients had appendiceal perforation (ICD-9 codes 540.0 and 540.1), 84 patients had non-perforated appendicitis (ICD-9 codes 540.9, 541, 542) and 23 had a negative appendectomy. Perforation percentage was defined as the total number of patients with appendiceal perforation divided by the number of patients with acute appendicitis. Negative appendectomy percentage was defined as the number of patients with appendectomy but without appendicitis divided by the total number of appendectomies.

Our independent variable was Body Mass Index (BMI) for age-gender percentile. Body mass index was calculated as weight in kilograms divided by height in meters squared, rounded to 1 decimal place. Percentiles were obtained from the 2000 CDC sex specific BMI-for age growth charts. Distribution of percentiles was categorized as underweight (0-15th), healthy weight (>15-85th), overweight (>85-95th), and obese (>95th).

Other variables included age, gender, type of insurance, type of hospital, number of physician examiners prior to diagnosis, co-morbidities, initial complete cell blood count (CBC), type of imaging studies, type of surgeon, type of surgical treatment, and complications. Time variables included onset of symptoms, time to diagnosis, time to surgery and time to discharge.

Statistical analysis

The statistical analysis was performed with STATA 11.0 statistical software (STATA Corp, College Station, TX, USA).

Univariate analysis was performed by group using one-way analysis of variance (one-way ANOVA) or Kruskal Wallis test (in case of no Gaussian distribution assumed). Bonferroni corrections were used to establish all possible pair wise comparisons to control for Type 1 error. For categorical variables, the Pearson's chi-square statistics (or the Fisher's exact test when applicable) were employed.

Bivariate analysis was performed using contingency tables. Odds ratio with their 95^{th} confidence intervals (CI) were used to study the association of baseline risk factors with perforation of the appendix. Finally, a multivariate logistic regression model for perforation of the appendix (perforated versus non-perforated groups) was developed, all variables with a p-value <0.05 in the bivariate analysis were included in the final model.

Statistical significance of all analyses was set at $p< 0.05$.

Results

There were 170 cases analyzed. Table 1 describes the demographic characteristics of the three study groups by perforation status. Higher rates of perforation were observed in children who were aged less than 5 years, with public (Reforma) or no insurance, with onset of symptoms over 36 hours and who were examined by more than 2 physicians prior to a surgeon's diagnosis ($p<0.05$). Hospital factors which were associated with higher rates of perforation were those children discharged from a public hospital (UPH, $p=0.004$). No statistical variations were found with gender or body mass index for age percentiles.

A higher frequency of complications was observed in the group with perforation. There were significant differences among the perforated group versus the non-perforated group in the abscess formation (18% vs 3.6%, $p=0.006$), post operative small bowel obstruction (10.9% vs 0%, $p=0.003$) and need for reoperation (10.9% vs 0%, $p=0.003$). Comorbidities were observed in 48% of all patients and the most common were asthma, gastroesophageal reflux and upper respiratory tract infections. There was no association among groups and the presence of comorbidities.

Odds of appendiceal perforation are presented in Table 2. As expected, it was observed that children aged less than 5 years had 10 times the odds of perforation when compared to the other age groups. The patients with lack of private insurance had almost 4 times the odds of having appendiceal perforation. Those children who were examined by more than 2 physicians had higher odds of having a perforation, as well as those who had symptoms longer than 36 hours. With regards to hospital factors, being discharged from a public hospital (UPH) had higher odds of having a perforation when compared to private hospital discharges. There were no significant associations in times to diagnosis and times to surgery.

Due to the fact that we did not find any significant association with BMI and perforation, and only a tendency toward perforation was observed in the obese group, our multivariate

logistic regression model included all variables that were significant in the bivariate analysis and all of them were adjusted to each other.

The only variables that remained significant in the multivariate analysis were age, onset of symptoms and time of surgery, which was marginally significant. Type of insurance, type of hospital, and number of physician examiners lost their independent status of predicting perforation on their own in presence of differences in age, onset of symptoms and time of surgery (Table 3).

Discussion

This study has identified some major problems in our health care systems that deserve serious attention. First of all, our perforation percentage in children ages 2-19 years was 38%, still above their national counterpart. Forty one percent of our pediatric population was overweight or obese. This finding supports our concerns that the overweight and obesity prevalence is increasing in our children[2]. Obesity and overweight were not found to be associated with appendiceal perforation, although it was interesting to observe a trend of increased perforation in the obese group.

From our data, it seems that pre-hospital factors are the most important aspects associated with perforation, in addition to age younger than 5 years, and onset of symptoms > 36 hrs. These findings are in concordance with the current literature [12-16]. Pre-hospital factors associated with lack of private/commercial insurance and an excessive number of examiners prior to arrival to hospital were of concern. Although significant in our bivariate analysis, these factors lost their power in the multivariate regression, most probably due to our small number of cases.

When we studied the times to diagnosis and times to surgery once the patient arrived to hospital, there were no significant differences among groups. Research has confirmed that in the United States there are no major delays to surgery after the proper diagnosis is made[16]. Our data seems to suggest that it is the same situation in these two hospitals. So, again, it seems that the major areas to be explored further are the pre-hospital factors and physician competency in making the right diagnosis without delay. Although obesity seems to be a critical problem in our society, our results failed to demonstrate an association with appendiceal perforation and its complications. Only a larger database could allow us to examine if this is a factor contributing to delays in the diagnosis of appendicitis.

Our study has several important limitations. The fact that it is retrospective accounts for lack of and incomplete information from the medical records. The number of medical records available for analysis was limited at both institutions due to storage of charts in remote areas away from the hospital. The numbers for calculations of BMI were obtained from data found in the chart and do not necessarily represent accurate data obtained from direct measurements from the patients.

We did not examine socioeconomic, geographic and specific referral patterns, family history, health and nutritional patterns in this group of patients, limiting our knowledge of prehospital factors that could have influenced delays in presentation and diagnosis. In addition, we only limited our study to two major pediatric hospitals and did not investigate scenarios at other community hospitals which have a limited number of general surgeons taking care of children with appendicitis. Furthermore the use of dichotomous variables limited causation and analysis for this condition.

Conclusions

We believe that we found disparities in the care of our population of children with appendicitis. Future work leads to prospective studies to investigate pre-hospital, socioeconomic and geographic factors affecting access and proper care. It should be our goal to promote treatment algorithms to general practitioners, pediatricians and family physicians that would assist in the proper diagnosis and management of children with abdominal emergencies such as appendicitis.

We could not prove that the body habitus of children who are obese could mislead or delay the diagnosis of appendicitis but we saw a tendency for them to present with perforation. We recommend physicians and health care providers to be on alert , be proactive and very thorough in their physical examination and their use of ancillary radiographical testing, as difficulties with the examination have been already reported in the obese adult population with appendicitis.

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References

1. Perez CM, Guzman M, Ortiz AP, et al. Prevalence of the metabolic syndrome in San Juan, Puerto Rico. Ethn Dis. 2008; 18(4):434–41. [PubMed: 19157247]
2. Otero Gonzalez M, Garcia Fragoso L. Prevalence of overweight and obesity in a group of children between the ages of 2-12 years in Puerto Rico. PR Health Sci J. 2008; 27(2):159–61.
3. Puerto Rico 2003-2005 BRFSS report. downloaded from : http://apps.nccd.cdc.gov/brfss/display.asp
4. Wang G, Dietz WH. Economic burden of obesity in youths aged 6-17 years: 1979-1999. Pediatrics. 2002; 109(5):E81–86. [PubMed: 11986487]
5. Krebs NF, Himes JH, Jacobson D, et al. Assessment of child and adolescent overweight and obesity. Pediatrics. 2007; 120(supp4):S193–228. [PubMed: 18055652]
6. Grimble RF. The true cost of in-patient obesity: impact of obesity on inflammatory stress and morbidity. Proc Nutr Soc. Jul 2.2010 :1–7.
7. Gamanagatti S, Vashisht S, Kappor A, et al. Comparison of graded compression ultrasonography and unenhanced spiral computed tomography in the diagnosis of acute appendicitis. Singapore Med J. 2007; 48(1):80–7. [PubMed: 17245521]
8. Hormann M, Scharitzer M, Stadler A, et al. Ultrasound of the appendix in children: is the child too obese? Eur Radiol. 2003; 13(6):1428–1431. [PubMed: 12764662]
9. Estadisticas Vitales de Puerto Rico, Departamento de Salud. Downloaded on July 2010from: http://www.salud.gov.pr/Datos/EstadisticasVitales/Tendencias/TGVM.pdf
10. Livingston EH, Woodward WA, Sarosi GA, et al. Disconnect between incidence of non perforated and perforated appendicitis. Implications for Pathophysiology and management. Annals of Surgery. 2007; 245(6):886–892. [PubMed: 17522514]

11. Aguilo J, Peiro S, Munoz C, et al. Adverse outcomes in the surgical treatment of acute apendicitis. Cir Esp. 2005; 78(5):312–7. [PubMed: 16420848]
12. Bratton SL, Haberken CM, Waldhausen JH. Acute appendicitis, Risk of complications: Age and Medicaid Insurance. Pediatrics. 2000; 106:75–8. [PubMed: 10878152]
13. Jablonski KA, Guagliardo MF. Pediatric appendicitis rupture rate: a national indicator of disparities in healthcare access. Popul Health Metr. 3:4. 205. [PubMed: 15871740]
14. Guagliardo MF, Teach SJ, Huang ZJ, et al. Racial and ethnic disparities in pediatric appendicitis rupture rate. Acad Emerg Med. 2003; 10:1218–27. [PubMed: 14597498]
15. Braveman P, Shaff VM, Egerter S, et al. Insurance-related differences in the risk of ruptured appendix. The New England J Med. 1994; 331:444–49.
16. Ponsky TA, Huang ZJ, Kittle K, et al. Hospital- and Patient Level Characteristics and the risk of appendiceal rupture and negative appendectomy in children. JAMA. 2004; 292:1977–1982. [PubMed: 15507583]
17. Estadisticas Vitales Puerto Rico. downloaded on July 16, 2010 from: http://tendenciaspr.uprrp.edu/salud/estadisticasvitales06/Tabla3_06.pdf
18. Salud en Puerto Rico. downloaded on July 16, 2010 from: http://tendenciaspr.uprrp.edu/salud/Reforma/planes_medicos_reforma_salud. htm
19. Chavier, R. Crisis de Salud en Puerto Rico. 2009. Downloaded from: http://www.asociacionmedicapr.org/president_desk/crisis_salud.pdf

Table 1

Characteristics of study group by perforation status (N=171)

Variable	Perforation n (%)			p-value
	Normal *23 (13.5%)*	**Non-perforated** *84 (48.8%)*	**Perforated** *64 (37.6%)*	
Demographic Characteristics				
Age *years*				**0.002**
≤ 5	5 (21.7)	3 (3.6)	16 (25.0)	
5-12	10 (43.5)	54 (64.3)	27 (42.2)	
13-19	8 (34.8)	27 (32.1)	21 (32.8)	
Age *years*				0.121
Mean (SD)	9.7 (4.6)	10.9 (3.5)	9.5 (4.6)	
Median (min-max)	9 (2-16)	10.5 (4-20)	9 (1.8-19)	
Gender				0.394
Female	5 (21.7)	31 (36.9)	22 (34.4)	
Male	18 (78.3)	53 (63.1)	42 (65.6)	
BMI (n=165)				0.478
Underweight	4 (18.2)	13 (15.9)	9 (14.8)	
Healthy weight	12 (54.6)	34 (41.5)	26 (42.6)	
Overweight	4 (18.2)	20 (24.4)	9 (14.8)	
Obese	2 (9.0)	15 (18.2)	17 (27.8)	
BMI percentile (n=165)				0.405
Mean (SD)	53.8 (35.9)	64.7 (34.0)	61.8 (35.8)	
Median (min-max)	54.5 (0.9-99)	79.5 (0.5-99)	73 (0.9-99.5)	
Insurance (n=164)				**0.002**
Private/Commercial	13 (61.9)	66 (82.5)	35 (55.6)	
Reforma/None	8 (38.1)	14 (17.5)	28 (44.4)	
Onset of symptoms (n=170)				**<0.0001**
< 36 hours	14 (60.9)	63 (75.9)	17 (26.6)	
≥ 36 hours	9 (39.1)	20 (24.1)	47 (73.4)	
Number of physicians (n=169)				**0.020**
< 2	17 (73.9)	65 (78.3)	36 (57.1)	
≥ 2	6 (26.1)	18 (21.7)	27 (42.9)	
Hospital factors				
Hospital				**0.004**
SJCH	12 (52.2)	65 (77.4)	34 (53.1)	
UPH	11 (47.8)	19 (22.6)	30 (46.9)	

Variable	Perforation n (%)			p-value
	Normal ***23 (13.5%)***	**Non-perforated** ***84 (48.8%)***	**Perforated** ***64 (37.6%)***	
Time to diagnosis *hours*				0.096
Mean (SD)	10.7 (10.9)	7.7 (5.9)	7.7 (10.1)	
Median	8 (0.25-51)	6.25 (0.33-34)	4.25 (0.08-59)	
Time to surgery *hours* (n=167)				0.449
Mean (SD)	5.4 (10.3)	3.4 (3.9)	18.2 (48.1)	
Median (min-max)	2.45 (0.33-51)	2.16 (0-24)	2.25 (0.33-240)	
Time of surgery *minutes* (n=167)				**0.002**
Mean (SD)	37.5 (22.3)	37.4 (18.2)	51.4 (31.4)	
Median (min-max)	35 (15-120)	31.5 (10-95)	35 (2.4-165)	
Type of surgery (n=162)				0.077
Open appendectomy	18 (78.3)	71 (84.5)	52 (94.6)	
Laparoscopic	5 (21.7)	13 (15.5)	3 (5.4)	
Type of surgeon				**<0.001**
Pediatric	13 (56.5)	39 (46.4)	51 (79.7)	
General	10 (43.5)	45 (53.6)	13 (20.3)	

Table 2

Odds ratios (OR) and 95% confidence interval (CI) for the association of risks factors for perforation of appendix.

Variable	OR (95% CI)	p-value
Demographic characteristics		
Age *years*		**<0.0001**
5-12	1.0	
≤ 5	10.7 (2.9-39.8)	
≥ 13	1.6 (0.8-3.2)	
Gender		0.751
Female	1.0	
Male	1.12 (0.6-2.2)	
BMI		0.683
Healthy weight	1.0	
Underweight	0.9 (0.3-2.4)	
Overweight	0.6 (0.2-1.5)	
Obese	1.5 (0.6-3.5)	
Insurance		**0.001**
Private/Commercial	1.0	
Reforma/None	3.8 (1.8-8.1)	
Onset of symptoms hours		**<0.0001**
< 36	1.0	
≥ 36	8.7 (4.1-18.4)	
Number of physicians		**0.007**
< 2	1.0	
≥ 2	2.7 (1.3-5.6)	
Comorbidities		0.893
No	1.0	
Yes	0.9 (0.5-1.8)	
Hospital factors		
Hospital		**0.002**
SJCH	1.0	
UPH	3.0 (1.49-6.13)	
Time to diagnosis *hours*		0.131
< 5.1	1.0	
≥ 5.1	0.6 (0.3-1.2)	
Time to surgery *hours*		0.865

Variable	OR (95% CI)	p-value
< 2.2	1.0	
≥ 2.2	1.1 (0.5-2.1)	
Time of surgery *minutes*		**0.001**
< 35	1.0	
≥ 35	3.2 (1.6-6.3)	
Type of surgery		0.083
Open appendectomy	1.0	
Laparoscopic	0.3 (0.09-1.2)	
Type of surgeon		**<0.0001**
General	1.0	
Pediatric	4.5 (2.1-9.5)	

Table 3

Multivariate logistic regression analysis for factors associated with perforation of the appendix (N=135)

Variable	OR (95% CI)	p-value
Age		**0.003**
> 5 years	1.0	
≤ 5 years	10.2 (2.2-46.7)	
Type of insurance		0.961
Private/Commercial	1.0	
Reforma/None	1.0 (0.3-3.6)	
Onset of symptoms		**<0.0001**
< 36 hours	1.0	
≥ 36 hours	5.9 (2.3-14.7)	
Number of physicians		0.738
< 2	1.0	
≥ 2	1.2 (0.4-3.2)	
Hospital Institution		0.592
SJCH	1.0	
UPH	0.6 (0.1-3.3)	
Time of surgery		**0.049***
< 30 minutes	1.0	
≥ 30 minutes	2.8 (1.0-7.8)	
Type of surgeon		0.197
General surgeon	1.0	
Pediatric surgeon	2.1 (0.7-6.4)	