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A dynamic postoperative protocol provides efficient care for pediatric patients with non-ruptured appendicitis

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ABSTRACT

Purpose: Postoperative management of pediatric patients with non-ruptured appendicitis is highly variable and often includes an overnight stay in the hospital. We implemented a criteria-based postoperative protocol designed to eliminate postoperative antibiotics and facilitate timely discharge by utilizing the bedside nurse to evaluate for readiness for discharge.
Methods: We collected data on all patients with non-ruptured appendicitis at our institution following protocol implementation (May 1, 2012 to April 30, 2013) and compared them to a control group.
Results: 580 patients were treated for non-ruptured appendicitis (285 prior protocol, 295 new protocol). Following implementation of our protocol, there was an overall reduction in length of stay from 40.1 (SD 27.5) to 23.5 (SD 20.8) h, and total cost of care per patient also decreased from $5783 (SD $2501) to $4499 (SD $1983) ($p < 0.001$). There was no change in hospital readmission rate (1.1% prior protocol, 1.4% new protocol) or postoperative abscess rate (0.8% prior protocol, 0.3% new protocol).
Conclusion: Our new protocol reveals the value of eliminating postoperative antibiotics and leveraging the continuous availability of the bedside nurse in the determination of readiness for discharge.

Acute appendicitis remains the most common urgent indication for surgery in children. Postoperative management of pediatric patients with non-ruptured appendicitis is variable and often includes an overnight stay in the hospital. Fortunately, the postoperative intra-abdominal abscess rate is less than 2% [1] and readmission rate is less than 6% [2]. Given the high clinical volume combined with the relative low frequency of complications, non-ruptured appendicitis represents a unique opportunity to increase value by implementing cost-saving measures, reducing length of stay (LOS) and reducing variability to minimize resource utilization. Increasing value is not only reliant on decreasing LOS and cost of care but also minimizing complications and hospital readmission [3,4]. Recently several authors have demonstrated the efficacy and safety of same-day discharge after appendectomy for non-ruptured appendicitis [5,6]. We created a new protocol designed to reduce LOS, reduce cost, eliminate postoperative antibiotics and improve value.

As guidelines for the management of pediatric appendicitis changed [7] we elected to revise our institutional treatment protocol for this common clinical problem. We implemented a dynamic criteria-based discharge protocol designed to eliminate the use of postoperative antibiotics and facilitate timely discharge by leveraging the bedside nurse evaluation of readiness for discharge.

In this study, we sought to evaluate the differences in resource utilization and patient outcomes between our prior protocol vs. our new protocol.

1. Methods

After obtaining institutional review board (IRB) (IRB no. 00064063) approval we performed a retrospective query of a prospectively maintained database at our tertiary care children's hospital. We changed our management protocol for children with non-ruptured appendicitis on May 1, 2012.

1.1. Prior protocol

In our prior protocol patients were made NPO at the time of diagnosis and started on IV fluid at maintenance rate and antibiotics (cefoxitin 40 mg/kg/dose IV). We ensured that a dose of antibiotics was given within 60 min before the skin incision by supplementing the above regimen with a single dose of cefoxitin when necessary. Postoperatively,

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patients with non-ruptured appendicitis variably received antibiotics (cefoxitin) based on the operating surgeon's perception of the severity of the appendicitis. Patients with gangrenous appendicitis received cefoxitin for at least 48 h.

Following appendectomy, patients were allowed to recover in the postoperative acute care unit (PACU) under the supervision of the anesthesiologist and nursing staff. IV fluids were given at maintenance rate and pain medications were given as necessary. After 30 to 60 min of observation the patient was then transferred to our standard surgical floor where they were monitored by the bedside nurse. Readiness for discharge was only assessed after patients completed their predetermined duration of IV antibiotic therapy. This assessment of discharge readiness was completed by the rounding surgical team and included lack of fever for 24 h (<38.5 °C), adequate oral intake (greater than the IV fluid maintenance rate by weight), pain control with oral medications, normal vital signs for age, and parent comfort with discharge. When patients met discharge criteria they were sent home with standard postoperative discharge instructions and oral pain medication. No oral antibiotics were given. Patients were evaluated in the clinic by an attending surgeon 2–3 weeks after discharge.

1.2. New protocol

Our new protocol was similar to our prior protocol except for the following:

- We standardized antimicrobial therapy to the combination of ceftriaxone (75 mg/kg IV Q24 h; 2000 mg max per dose) and metronidazole (10 mg/kg IV Q8 h; 500 mg max per dose).
- We eliminated postoperative antibiotics.
- Discharge readiness was assessed every 2 h by the bedside nurse.
- When all discharge criteria (same as criteria as our prior protocol) were met the bedside nurse contacted the surgical team immediately for discharge orders.

1.3. Inclusion criteria

Patients with non-ruptured appendicitis who had an appendectomy (either laparoscopic or open) at our institution during their initial hospital stay between May 1, 2012 and April 30, 2013 were managed using the new protocol and were included in this analysis. Historical controls treated with our prior protocol included patients with non-ruptured appendicitis who had an appendectomy (either laparoscopic or open) at our institution during their initial hospital stay between May 1, 2010 and April 30, 2011. All patients in both protocol groups were less than 19 years old.

1.4. Exclusion criteria

Patients with ruptured appendicitis or other confounding intra-abdominal processes such as ventriculoperitoneal shunt or volvulus were excluded from the study. We did not exclude patients with urinary tract infections, enteritis, or pneumonia from the study.

1.5. Definition of non-ruptured appendicitis

We strictly defined ruptured appendicitis as a visible hole in the appendix or a fecalith in the abdomen [1]. All patients without a visible hole in the appendix or a fecalith in the abdomen were treated as non-ruptured appendicitis at our hospital. Patients with gangrenous appendicitis were included in this analysis as non-ruptured appendicitis in both the prior protocol and new protocol groups. The non-ruptured status was based upon intra-operative status and did not change through the hospital course. Pathologic results did not affect how patients were treated postoperatively. If the appendix was ruptured intra-operatively due to surgical manipulation, that patient was categorized as "ruptured" and excluded from this study.

1.6. Definition of admission types

An admission to the hospital begins when the patient is admitted to the inpatient floor of the hospital and ends with discharge. LOS begins when the patient is admitted to the floor or taken to the OR directly from the ED or outside hospital and ends with discharge from the hospital. The LOS includes any time spent on the inpatient floor prior to appendectomy. Patients are not allowed to wait in the ED before appendectomy. Most patients are admitted from the ED to the inpatient floor where they wait for the appendectomy to occur.

An observation readmission is defined as an admission to special observation unit in our hospital located near the ED. It can last no longer then 24 h without requiring transfer to an inpatient floor. Patients can be sent to the observation unit from the ED or clinic.

LOS, cost of care and doses of antibiotics of any readmission (observation or regular admission) at our hospital or any other hospital in our care system within 30 days of the appendectomy were included in the total LOS, cost of care and total number of doses of antibiotics for this patient in this analysis. Additionally, the inclusion of patients with both pre- and postoperatively diagnosed urinary tract infections, pneumonia, and other potentially appendicitis-related issues dramatically increased the range of the primary outcome data (LOS, cost of care, and doses of antibiotics).

1.7. Activity-based accounting

Costs were derived from the hospital's cost-accounting program, the Standard Cost Master, which is a transaction-based microcosting system. This system identifies and aggregates the variable- and fixed-cost components of patient activities, hospital services, and products according to the date of service [8,9]. Total hospital charges are shown. Hospital costs and charges incurred in years 2010–2013 were standardized to 2010 US dollars by applying a yearly consumer price index for hospital services [10]. Cost reported in this analysis include the cost of the initial evaluation, procedure, hospital stay and all other costs incurred during a 30-day postoperative window.

1.8. Statistical analysis

A logistic regression model was used to determine the effect of the two protocol periods on patient outcome measures including inpatient readmission, observation readmission, post discharge emergency department evaluation, abdominal abscess, subcutaneous abscess, *Clostridium difficile* colitis, postoperative CT imaging, reoperation for subcutaneous abscess, interventional radiology for intra-abdominal abscess and a conglomerate variable of all outcome measures combined, after controlling for age and gender. A generalized linear model was used to determine the effect of the two protocol periods on the outcomes of LOS in hours, and cost of care in US dollars after controlling for age, gender and severity of illness. Results are expressed as adjusted means with standard deviation.

The use of antibiotics was analyzed using a two stage model. First, the effect of the protocol period on the probability of any antibiotic use was analyzed using a logistic regression model. In the second stage, only those who received antibiotics were considered. The number of doses was modeled using a log-gamma generalized linear model with protocol as the predictors. The gamma distribution correctly models very skewed data.

The effect of the protocol period on cost data was analyzed using a generalized linear model with the inverse Gamma distribution with the log link function after controlling for age.

Significance was defined as P value $\leq .05$. Descriptive statistics were calculated as mean with standard deviation or N (%).