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A Prospective Study of 113 Deep Neck Infections Managed Using a Clinical Practice Guideline

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Objectives/Hypothesis: Retropharyngeal abscesses are a difficult to diagnose condition in children. Though some children with such abscesses can be managed with intravenous (IV) antibiotics alone, our group has argued that surgical drainage is the gold standard for safe management and likely leads to shorter hospital stays. We present prospective data on children with retropharyngeal infections who were managed according to a clinical practice guideline that emphasizes reliance on computed tomography and prompt surgical drainage when pus is felt to be present.

Study Design: Prospective observational study at a tertiary care children's hospital.

Methods: Children were included in the study if a retropharyngeal infection was suspected and they were treated according to the clinical guideline between July 2001 and March 2004.

Results: Of 111 children in the study, 73 were ultimately treated with incision and drainage. There was no long-term morbidity or mortality. Surgical patients were more likely to require an intensive care unit (ICU) admission than patients managed with IV antibiotics alone (26.0% vs. 5.3%, $P < .01$) and on average cost nearly $8,000 more ($22,071 and $14,950; $P < .01$). However, these results may be biased, as patients requiring surgery were younger, which likely influenced the decision for ICU admission.

Conclusions: It is possible to treat pediatric retropharyngeal infections according to our clinical guideline with nearly zero long-term morbidity and mortality. Our data showed good outcomes for both groups, and substantially higher costs for patients treated surgically. These results cannot be regarded as definitive, because surgery was consistently advised for all patients with suspected pus, and because the surgical group was younger than the nonsurgical group.

Key Words: Pediatric infectious/inflammatory, retropharyngeal abscess, prospective study, clinical practice guideline, cost analysis.

Level of Evidence: 2c.

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INTRODUCTION

Retropharyngeal abscess (RPA) is an uncommon but potentially life-threatening condition in children. Although improved imaging, operative management, and antibiotics have led to a decrease in the morbidity resulting from RPAs,[1] complications such as mediastinal spread[2–5] and airway obstruction[6] can still occur. Moreover, an increase in the overall incidence of this condition has been observed in the literature,[3] as has an increasing prevalence of methicillin-resistant *Staphylococcus aureus* as the pathogenic organism.[7–9] Although we have previously argued that surgical incision and drainage is the gold standard for management of a true RPA,[1] others have reports that these patients can be managed with intravenous (IV) antibiotics.[10,11]

The diagnosis of abscess versus phlegmon or cellulitis remains difficult. Presenting symptoms of deep neck infections are variable,[10] and there is no definitive sign or symptom to distinguish the presence of drainable pus. There is no clinical or computed tomography (CT) finding that is both highly sensitive and highly specific in predicting true abscess formation[1,10,12,13] or failure of medical management.[11]

Because varied diagnostic criteria and treatment plans are used by different physicians, we saw an opportunity for standardization and improvement through development of clinical practice guidelines (CPGs). To our knowledge no studies have looked prospectively at children presenting with signs and symptoms *of* a possible RPA. In this article, we present prospective data on

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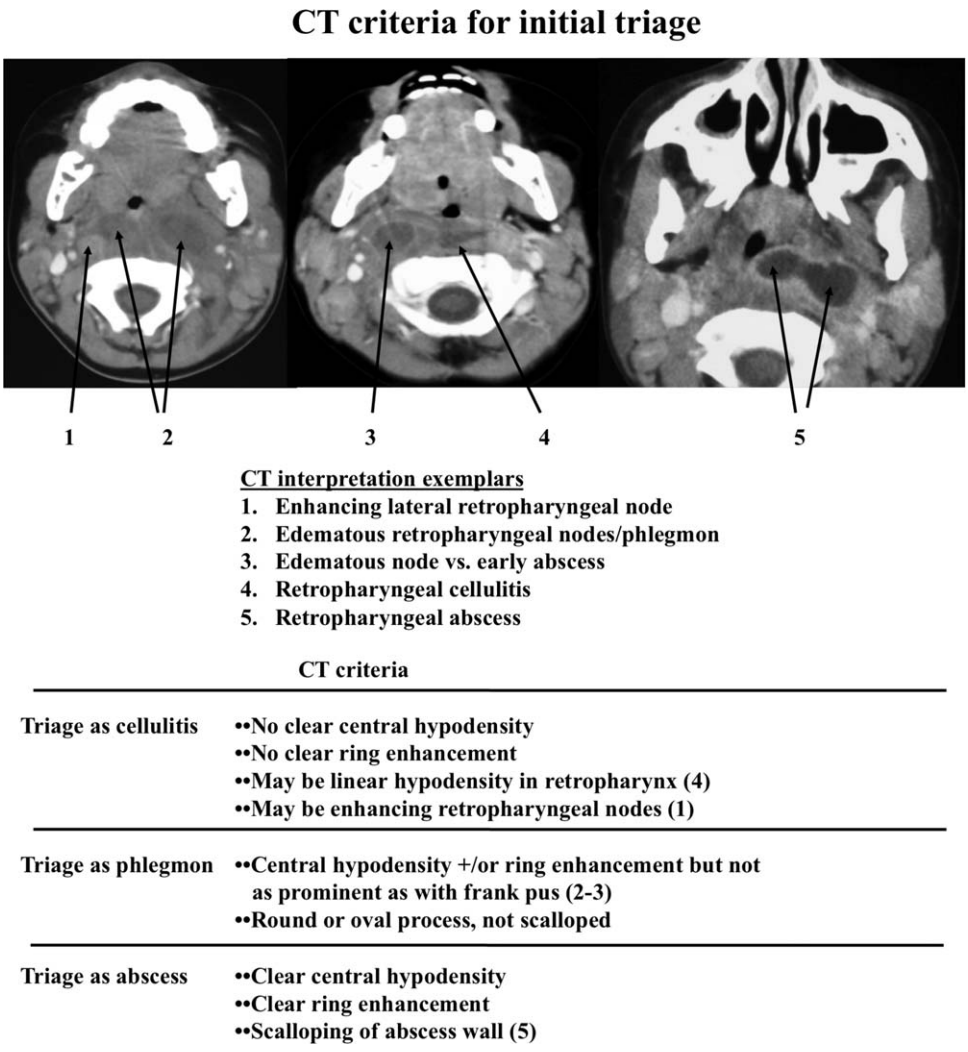

Fig. 1. Computed tomography (CT) criteria for initial triage of patient as having either cellulitis, phlegmon, or abscess.

children who were managed according to our practice guideline.

MATERIALS AND METHODS

CPG Development

Members of the Departments of Otolaryngology (ORL), Pediatrics, Emergency Medicine, Radiology, and Quality Improvement met and agreed on a standardized diagnostic and treatment plan, including agreement on standard criteria for CT interpretation, patient triage, and patient flow (e.g., which services would admit patients). Several iterations of the CPG were circulated to all ORL faculty as well as selected faculty in the pediatrics, emergency medicine, and radiology departments. Input was actively sought out and incorporated. ORL trainees were oriented to the CPG at the start of their rotation, and all emergency department (ED) attendings were repeatedly notified by email. The CPG was available 24/7 on our institution's internal Web page.

CPG Management Algorithm

The management plan of our CPG consists of initially assessing clinical suspicion in the ED, or if the patient is an inpatient, on the floor. Patients with very low suspicion may not need to be imaged or may only have a lateral neck film. Patients with moderate or high clinical suspicion have a neck CT with contrast; if there is concern about the airway the patient may be intubated in the operating room (OR) prior to CT. Following a CT scan, patients are triaged based on defined radiographic criteria into three groups:

1. Probable cellulitis without phlegmon or significant adenopathy: The CPG calls for these patients to be treated with IV antibiotics for 48 hours and discharged on oral antibiotics with close follow-up if clinically well (defined as the absence of fevers, toxic appearance, tachycardia, and the presence of good oral intake and a stable clinical exam).
2. Probable phlegmon (early seminecrotic node): Our previous study showed that many of these patients progress to frank abscess. Therefore, the CPG calls for these patients to be admitted on IV Unasyn (Pfizer Injectables, New York, NY) for 48 to 72 hours and then to be rescanned. If abscess has developed, it is drained. If phlegmon persists, the child is discharged on home IV antibiotics
3. Probable abscess. These patients are taken promptly to the OR for drainage. Once they are clinically well and afebrile for 24 hours, they are converted to oral antibiotics and discharged with close follow-up.

TABLE I.
Patient Characteristics (N = 111).

Demographics	
Average age, mo	61.8
Percent female	36.9
Percent transferred	37.8
Signs and symptoms	
Percent with fever	91.9
Percent with stiff neck/torticollis	68.5
Percent with neck mass on exam	65.8
Percent reporting poor PO	58.6
Percent with previous abx	32.4
Percent with drooling	21.6
Percent with odynophagia	19.8
Percent with OSA	18.0
Percent with voice changes	15.3
Percent with stridor	3.6
Percent with h/o ORL surgery	8.1
Comorbidity and sequellae	
Percent with blood culture taken	50.1
Percent with positive blood culture	0.0
Percent positive for strep	31.5
Percent positive for mono	5.4
Percent diagnosed with Kawasaki's	3.6
Percent evaluated for Grisel's syndrome	1.8
Percent with nephritic syndrome	0.9

abx = antibiotics; h/o = history of; mono = mononucleosis; ORL = otolaryngology; OSA = obstructive sleep apnea symptoms; PO = oral intake; strep = *Streptococcus pyogenes*.

The CPG includes defined discharge criteria for each group as well as criteria for additional scans or other interventions. As with all CPGs, the managing clinician is always free to customize care based on his/her assessment of the patient's situation, departing from the CPG when appropriate. Although we did not categorize the indications where management varied from the guidelines, substantial deviations from the algorithm were rare.

Because it has historically been difficult to obtain standardized CT interpretations from different members of the Radiology Department, particularly at night, we developed an annotations "cheat sheet" to assist in the interpretation of CT findings and to help standardize triage (Fig. 1). Approximately 15 different otolaryngologists and a large number of radiologists including call and coverage radiologists were involved in the implementation of the CPG.

Study Design

This prospective, observational study was conducted in a tertiary care children's hospital. Children were included in the study if a deep neck infection was suspected, they were treated according to the CPG between July 2001 and March 2004, and had at least one CT scan. There were no exclusion criteria. The Children's Hospital of Boston internal review board approved the study. Informed consent was obtained from the parents or guardian of all participants.

Cost Estimates

Cost estimates for each patient's care was made using data from hospital accounting and reflects the cost to the hospital based on whether the patient had a complete blood count, a peripherally inserted central catheter (PICC) placement, *Streptococcus pyogenes* (strep) test, heterophile antibody test, blood culture, and/or wound culture as well as each patient's number of CT scans, number of trips to the OR, duration of IV antibiotics, hospital floor days, and intensive care unit (ICU) days. In addition, the cost of a level 4 ED visit was included in the cost estimation for each patient. Cost of a PICC includes the cost of PICC placement and inpatient nursing instruction. Cost of the strep test is based on the cost of a rapid streptococcal antigen test and a throat culture; blood culture costs include both anaerobic and aerobic cultures. Operative costs include 85 minutes of OR time (based on average OR time from a limited sample of our data) as well as surgeon's fee for retropharyngeal abscess. The cost of IV antibiotics is based on the average cost of IV Unasyn and clindamycin.

Data Analysis

The unit of analysis was the individual patient. Hypothesis testing was done to assess differences between patients on the cellulitis, phlegmon, and abscess pathway; between patients who were managed surgically versus medically; and between patients with or without pus on drainage. Categorical variables were compared using χ^2 test or Fisher exact test, and continuous variables were compared using two-tailed heteroscedastic t tests or one-way analysis of variance. All analyses were done using Stata (StataCorp, College Station, TX).

RESULTS

A total of 113 patients were included in the study. Two patients, aged 9 months and 54 months, presented with RPAs complicated by mediastinal extension. The younger patient had a complicated clinical course including multiple surgical debridements, positive blood cultures treated with multiple antibiotics, and prolonged intubation. The older patient was managed with IV antibiotics only and was readmitted after discharge due to resumed neck pain and torticollis as well as concern for incomplete antibiotic coverage. These two outliers were excluded from the statistical analyses.

Of the remaining patients in the study (N = 111), 63.1% were male and nearly half were younger than 4 years of age (mean, 61.8 months; standard deviation, 45.5 months). More than one-third of patients were transferred from outside hospitals (37.8%). The most common signs and symptoms at presentation were fever (91.9%), torticollis (68.5%), neck mass (65.8%), and poor oral intake (58.6%). Nearly all had an elevated white blood count (WBC) upon presentation (81.1%) (Table I).

Blood cultures were taken from half of the patients; none were positive. However, 31.5% of patients tested positive for strep throat and 5.4% of patients tested positive for mononucleosis. In addition, four patients were diagnosed with Kawasaki's disease during their admission, two patients were evaluated for Grisel's syndrome, and one patient's clinical course was complicated with nephritic syndrome.

All but one patient underwent at least one CT scan, and the majority (74.7%) had two or more CTs; nine patients (8.1%) had three or more CT scans. All patients were treated with IV antibiotics and received either Unasyn or clindamycin. The median length of IV

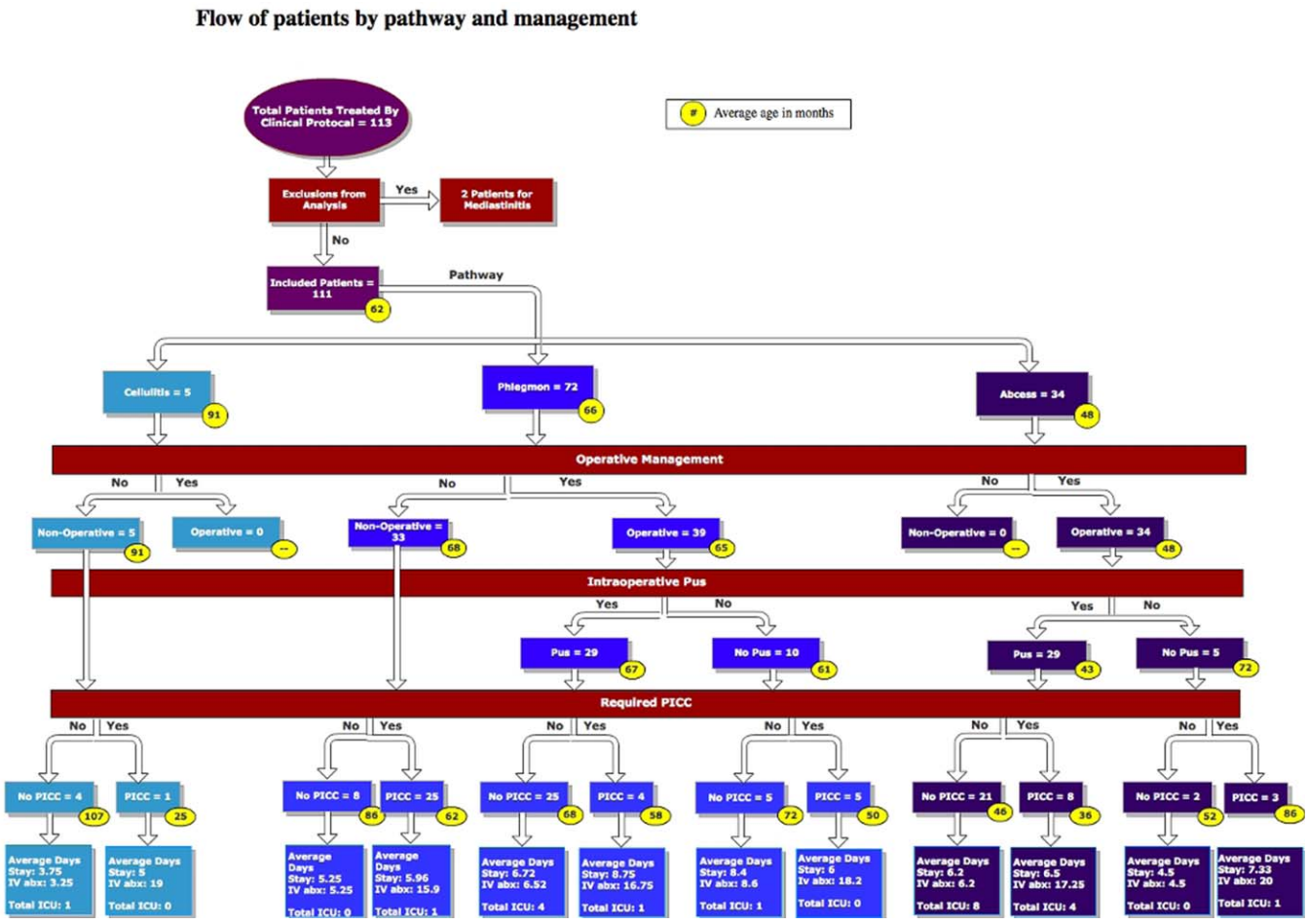

Fig. 2. Flow of patients according to pathway (cellulitis, phlegmon, or abscess), surgical management (operative versus nonoperative), outcome (drainage of pus), and peripherally inserted central catheter (PICC) requirement. Yellow circles indicate mean age in months of patients in the given category. Stay indicates average length of stay for the group. ICU = intensive care unit; IV abx = average duration the group requiring intravenous antibiotics. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

antibiotics was 8 days (mean, 10.6 days), and nearly half (41.4%) of all patients required a PICC.

Twenty-one patients (18.9%) required ICU admission, almost all because of concern for airway compromise. Patients requiring ICU care were significantly younger (mean, 28.6 months vs. 69.5 months; $P < .01$). ICU patients also had longer hospital stays (8.4 days vs. 5.8 days, $P < .01$).

Pathways

The pathways of the 111 patients included in the study are summarized in Figure 2. Five patients (4.5%) were categorized as having cellulitis upon admission, 72 (64.9%) were categorized as probable phlegmon, and 34 (30.6%) were categorized as probable abscess. Table II shows differences in presentation and management between the three pathways. Cellulitis patients were the oldest (91.0 months) followed by phlegmon (66.4 months) and abscess patients (47.6, $P < .05$). There were no significant differences between the pathways in the clinical presentation of patients. Patients triaged as probable phlegmon, whose diagnosis is by definition somewhat uncertain, received significantly more CT scans ($P < .01$). Patients triaged as probable abscess (and were therefore taken promptly to the OR) were more likely to require a stay in the ICU ($P < .01$).

Pathway 1: probable cellulitis. Only five patients were triaged as probable cellulitis. None of these children were managed operatively, and only the youngest (14 months) required an ICU admission.

Pathway 2: probable phlegmon. Of the 72 phlegmon patients, all but four (5%) had a repeat CT scan after 48 to 72 hours of antibiotics. Thirty-nine (54.2%) ultimately required surgical drainage; of these, 29 (74.4%) patients had pus found at surgery. Seven of these patients required an ICU admission. In this group, those who ultimately came to surgical drainage were significantly less likely to require a PICC (23.1% vs. 75.8%, $P < .01$) (Table III) and required a significantly shorter duration of antibiotics (9.3 days vs. 13.4 days, $P < .01$) when compared to patients managed with IV antibiotics only. However, phlegmon patients who came to surgery had a significantly longer inpatient length of stay (mean, 7.1 vs. 5.8; $P < .05$).

Pathway 3: probable abscess. Per protocol, all 34 patients who were placed on the abscess pathway had

TABLE II.
Comparison of Pathways.

	Cellulitis (n= 5)	Phlegmon (n = 72	Abscess (n = 34)	*P*
Demographics				
Average age, mo	91.0*	66.4	47.7*	.05*
Percent transferred	40.0	43.1	26.5	.26
Signs and symptoms				
Percent with fever	80.0	94.4	88.2	.34
Percent with stiff neck/torticollis	60.0	69.4	67.7	.90
Percent with neck mass on exam	80.0	68.1	67.7	.09
Percent reporting poor PO	40.0	54.2	70.6	.19
Percent with previous abx	60.0	26.4	41.2	.13
Percent with drooling	20.0	25.0	14.7	.48
Percent with odynophagia	20.0	22.2	14.7	.66
Percent with OSA	20.0	22.2	8.8	.24
Percent with voice changes	0.0	18.1	11.8	.44
Percent with stridor	0.0	4.2	2.9	.86
Percent with h/o ORL surgery	0.0	12.5	0.0	.07
Laboratory values				
Percent with elevated WBC at admission	100.00	77.8	85.3	.36
Average WBC at admission	20.3	26.6	23.2	.79
Average WBC without outlier	20.3	22.6	23.2	.78
Average PMN	68.4	76.4	74.5	.34
Radiology				
Percent who had plain film done	20.0	38.9	47.1	.46
Percent who had plain film with fullness	20.0	78.6	81.3	.86
Percent with 0 CTs	20.0	0.0	0.0	—
Percent with 1 CT	80.0	5.6	55.9	—
Percent with 2 CTs	0.0	84.7	38.2	—
Percent with 3 CTs	0.0	8.3	5.9	—
Percent with 4 or more CTs	0.0	1.4	0.0	—
Average number of CTs	0.8*	2.1*	1.5*	<.01*
Operative management				
Percent who had I&D attempted	0.0*	54.2*	100.0*	<.01*
Percent with pus	—	74.4	80.0	.25
Medical management				
Average length of stay	4.9	6.5	6.3	.20
Percent requiring ICU	20.0*	9.7*	38.2*	<.01*
Percent requiring PICC	20.0	47.2	32.4	.21
Average length of IV abx	6.4	11.2	9.9	.22
Percent positive for strep	40.0	31.9	29.4	.89
Percent positive for mono	0.0	6.9	2.9	.60
Average total cost estimate (US$)	$10,490*	$18,969*	$22,385*	.04*†

*Significant at $P < .05$.
†In robustness check where surgeon's fee is excluded, this loses significance.
abx = antibiotics; CT = computed tomography; h/o = history of; I&D = incision and drainage; ICU = intensive care unit; IV = intravenous; mono = mononucleosis; ORL = otolaryngology; OSA = obstructive sleep apnea symptoms; PICC = peripherally inserted central catheter; PO = oral intake; PMN = polymorphonuclear leukocyte count; strep = *Streptococcus pyogens*; WBC = white blood count.

prompt incision and drainage. Of these, 29 (85.3%) had frank pus upon incision and drainage. Thirteen of the abscess patients (38.2%) required an ICU admission. Eleven abscess patients (32.4%) required a PICC despite surgical drainage due to failure to meet criteria for discharge on oral antibiotics (absence of fevers for 24 hours, tachycardia, systemic signs of infection or toxic appearance; and the presence of good liquid intake and stable airway and neck exam) within 2 to 3 days of drainage.

Operative Versus Medical Management

In total, 73 patients (65.8%) were ultimately treated with incision and drainage. Thirty-four of these (46.6%)

were initially triaged as probable abscess and taken promptly to the OR; 39 (53.4%) were initially triaged as probable phlegmon but taken to the OR after repeat CT showed progression of disease (Table IV). Of these 73 patients, 10 (13.7%) returned to the OR at least once for

TABLE III.
Operative Versus Medical Management of Phlegmon.

	Phlegmons Operatively (n = 39)	Phlegmons Medically (n = 33)	*P*
Demographics			
Average age, mo	65.3	67.7	.83
Percent transferred	51.3	47.9	.13
Signs and symptoms			
Percent with fever	94.9	93.9	.86
Percent with stiff neck/torticollis	71.8	66.7	.64
Percent with neck mass on exam	64.1	72.7	.43
Percent reporting poor PO	53.9	54.5	.95
Percent with previous abx	20.5	33.3	.22
Percent with drooling	25.6	24.2	.89
Percent with odynophagia	28.2	15.2	.18
Percent with OSA	23.1	21.2	.85
Percent with voice changes	12.8	24.2	.21
Percent with stridor	5.1	3.0	.66
Percent with h/o ORL surgery	23.1*	3.0*	.03*
Laboratory values			
Average WBC at admission	32.3	19.9	.10
Average WBC outlier excluded	25.0*	19.9*	.01*
Percent with elevated WBC at admission	79.5	75.8	.70
Average PMN	77.7	75.1	.34
Radiology			
Percent who had plain film done	43.6	33.3	.37
Percent who had plain film with fullness	82.4	72.7	.54
Percent with 0 CTs	0.0	0.0	—
Percent with 1 CT	5.1	6.1	—
Percent with 2 CTs	79.5	90.9	—
Percent with 3 CTs	12.8	3.0	—
Percent with 4 or more CTs	2.6	0.0	—
Average number of CTs	2.1	2.0	.11
Operative management			
Percent who had I&D	100.0	—	—
Percent with pus	74.4	—	—
Medical management			
Average length of stay	7.1*	5.8*	.02*
Percent requiring ICU	15.4	3.0	.08
Percent requiring PICC	23.1*	75.8*	<.01*
Average length of IV abx	9.3*	13.4*	<.01*
Percent positive for strep	35.9	27.3	.43
Percent positive for mono	7.7	6.1	.79
Average total cost estimate (US$)	$21,798*	$15,627*	<.01*

*Significant at $P < .05$.

abx = antibiotics; CT = computed tomography; h/o = history of; I&D = incision and drainage; ICU = intensive care unit; IV = intravenous; mono = mononucleosis; ORL = otolaryngology; OSA = obstructive sleep apnea symptoms; PICC = peripherally inserted central catheter; PO = oral intake; PMN = polymorphonuclear leukocyte count; strep = *Streptococcus pyogens*; WBC = white blood count.

TABLE IV.
Operative Versus Nonoperative Management.

	All OR Cases (n = 73)	All non-OR Cases (n = 38	*P*
Pathway			
Percent cellulitis pathway	0.0	18.4	—
Percent phlegmon pathway	53.4	81.6	—
Percent abscess pathway	46.6	0.0	—
Demographics			
Average age, mo	57.1	70.8	.17
Percent transferred	39.7	34.2	.57
Sign and symptoms			
Percent with fever	91.8	92.1	.95
Percent with stiff neck/torticollis	69.9	65.8	.66
Percent with neck mass on exam	65.8	65.8	.99
Percent reporting poor PO	61.6	52.6	.36
Percent with previous abx	30.1	36.8	.28
Percent with drooling	20.5	23.7	.70
Percent with odynophagia	21.9	15.8	.44
Percent with OSA	16.4	21.1	.55
Percent with voice changes	12.3	21.1	.23
Percent with stridor	4.1	2.6	.69
Percent with h/o ORL surgery	11.0	2.6	.13
Laboratory values			
Average WBC at admission	28.2	19.8	.05
Average WBC at admission without outlier	24.2*	19.8*	<.01
Percent with elevated WBC at admission	82.2	78.9	.68
Average PMN	76.1	74.1	.47
Radiology			
Percent who had plain film done	45.2	31.6	.17
Percent who had plain film with fullness	81.8	75.0	.61
Percent with 0 CTs	0.0	2.6	—
Percent with 1 CT	28.8	15.8	—
Percent with 2 CTs	60.3	79.0	—
Percent with 3 CTs	9.6	2.6	—
Percent with 4 or more CTs	1.4	0.0	—
Average number of CTs	1.8	1.8	.86
Operative management			
Percent who had I&D attempted	100.0	—	—
Percent with pus	79.5	—	—
Wound culture sent	88.6	—	—
Group A strep	27.4	—	—
Viridans streptococci	14.5	—	—
Staphylococcus aureus	12.9	—	—
Medical management			
Average length of stay	6.7	5.6	.05
Percent requiring ICU	26.0*	5.3*	.01*
Percent requiring PICC	27.4*	68.4*	<.01*
Average length of IV abx	9.6*	12.5*	.02*
Percent positive for strep	32.9	28.9	.67
Percent positive for mono	5.5	5.3	.96
Average total cost estimate (US$)	$22,071	$14,951	<.01*

*Significant at $P < .05$.

abx = antibiotics; CT = computed tomography; h/o = history of; I&D = incision and drainage; ICU = intensive care unit; IV = intravenous; mono = mononucleosis; OR = operating room; ORL = otolaryngology; OSA = obstructive sleep apnea symptoms; PICC = peripherally inserted central catheter; PO = oral intake; PMN = polymorphonuclear leukocyte count; strep = *Streptococcus pyogens*; WBC = white blood count.

TABLE V.
Operative Cases With and Without Pus.

	OR Cases With Pus (n = 58)	OR Cases Without Pus (n = 15)	*P*
Pathway			
Percent cellulitis pathway	0.0	0.0	
Percent phlegmon pathway	50.0	66.7	.25
Percent abscess pathway	50.0	33.3	.25
Demographics			
Average age, mo	55.1	64.9	.38
Percent transferred	36.2	53.3	.23
Signs and symptoms			
Percent with fever	94.8	80.0	.06
Percent with stiff neck/torticollis	67.2	80.0	.34
Percent with neck mass on exam	69.0	53.3	.26
Percent reporting poor PO	62.1	60.0	.88
Percent with previous abx	29.3	33.3	.76
Percent with drooling	20.7	20.0	.95
Percent with odynophagia	22.4	20.0	.84
Percent with OSA	19.0	6.7	.25
Percent with voice changes	12.1	13.3	.89
Percent with stridor	5.2	0.0	.37
Percent with h/o ORL surgery	8.6	20.0	.21
Laboratory values			
Average WBC at admission	29.4	23.0	.28
Average WBC without outlier	24.5	23.0	.64
Percent with elevated WBC at admission	84.5	73.3	.31
Average PMN	75.3	78.7	.23
Radiology			
Percent who had plain film done	48.3	33.3	.30
Percent who had plain film with fullness	78.6	100.0	.25
Percent with 0 CTs	0.0	0.0	—
Percent with 1 CT	32.8	13.3	—
Percent with 2 CTs	56.9	73.3	—
Percent with 3 CTs	10.3	6.7	—
Percent with 4 or more CTs	0.0	6.7	—
Average number of CTs	1.8	2.1	.16
Medical management			
Average length of stay	6.7	6.9	.82
Percent requiring ICU	29.3	13.3	.21
Percent requiring PICC	20.7*	53.3*	.01*
Average length of IV abx	8.6*	13.5*	.02*
Percent positive for strep	31.0	40.0	.51
Percent positive for mono	5.2	6.7	.82
Average cost estimate (US$)	$22,122.79	$21,871.77	.94

*Significant at $P < .05$.
abx = antibiotics; CT = computed tomography; h/o = history of; ICU = intensive care unit; IV = intravenous; mono = mononucleosis; OR = operating room; ORL = otolaryngology; OSA = obstructive sleep apnea symptoms; PICC = peripherally inserted central catheter; PO = oral intake; PMN = polymorphonuclear leukocyte count; strep = *Streptococcus pyogens*; WBC = white blood count.

repeat drainage. Seventy (95.9%) were drained transorally; two patients (2.7%) required an external approach for extension of the abscess lateral to the great vessels. Three patients (4.1%) also had transcervical incisions and drainage of concurrent (but not connected) zone V external neck abscesses.

There were no significant differences in presenting signs or symptoms between patients managed surgically versus those managed with IV antibiotics only. However, surgical patients had higher average WBC on admission (mean, 24.2 and 19.8; $P < .01$), were more likely to require an ICU admission (26.0% vs. 5.3%, $P < .01$), less likely to require a PICC (27.4% and 68.4%, $P < .01$), and had a shorter duration of IV antibiotics (mean, 9.6 days and 12.5 days; $P = .02$)

Of the 73 patients who were treated surgically, 58 (79.5%) had purulent drainage. Fever and history of prior surgery were significant predictors of purulence upon operative drainage (Table V). Patients with frank pus on drainage were less likely to receive a PICC (20.7% and 53.3%, $P = .01$) and had a shorter duration of IV antibiotics (8.6 and 13.5, $P < .01$)

Estimated Cost of Management

Generally, the most costly treatment items provided to patients were operative management ($4,379 per OR trip), ICU management ($3,541 per day), and PICC line placement (>$2,000). Patient's triaged into the abscess pathway had the highest costs ($22,384 per patient), whereas those triaged to the phlegmon and cellulitis pathways had average costs of $18,969 and $10,490, respectively. The average cost for patients managed surgically was nearly $8,000 more than those managed with IV antibiotics alone ($22,071 vs. $14,950, $P < .01$).

DISCUSSION

In this prospective observational study of patients with deep neck infections managed according to a clinical practice guideline, the main finding that emerges, as amply demonstrated in the previous literature, is that deep neck infections are confusing and challenging to diagnose and treat. Despite using a practice guideline, a standardized "cheat sheet" for interpretation of CT scans, and rescanning those children with equivocal findings to check for disease progression, 21% of the children who were taken to the OR because abscess was believed to be present did not have pus at surgery. This is consistent with many previous studies.[10,13,14]

Analysis of multiple clinical variables did find some association with pus; younger children and children with higher white counts were slightly more likely to have pus. However, because many children without pus also had these findings, their positive predictive value was modest. Unfortunately, the clinician treating a child with fever, torticollis, and equivocal findings on CT will not, in our data, find any algorithm that would allow him or her to substantially improve their ability to predict whether pus is present.

We have previously argued[1] that if pus is present, prompt drainage followed by rapid conversion to oral antibiotics and discharge not only allows children to feel better sooner, but also allows earlier discharge and

reduces the likelihood of the child needing a PICC, and is therefore cost-effective. Our power analysis suggested that we would be unable to conduct an adequately powered randomized trial of prompt surgical drainage versus an initial trial of IV antibiotics, so we instead conducted a prospective observational study of children managed according to our practice guidelines.

Because children in this study were not randomized to the different treatments, but were assigned based on the estimated probability of pus being present, and because those who came to surgery were substantially younger than those who did not, the value of any comparison is limited. However, to the extent that one can draw any conclusions from our data, they do not support the hypothesis that prompt drainage results in better outcomes, shorter hospital stay, or reduced cost of care.

CONCLUSION

Despite attempts to standardize management and CT interpretation, our ability to predict pus was no greater than what has been previously reported. Diagnosis and management of pediatric deep neck infections remain challenging. We conclude, nonetheless, that it is possible to manage suspected deep neck infections according to a practice guideline that favors liberal use of CT and prompt surgical drainage, with close to zero long-term morbidity and mortality.

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