Implementation of decision support for the evaluation of new fever in the pediatric intensive care unit

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Introduction

Broad context: There is variability in diagnostic testing practices among pediatric intensive care unit (PICU) patients.[1,2] Clinical decision support tools can standardize testing practices.

Specific context: Previously, our PICU implemented blood culture guidelines and endotracheal aspirate culture guidelines.[3,4] Investigation of practices suggested there was still variability in PICU clinician practices.[5] Staff feedback suggested using a single streamlined guideline applicable to PICU patients with new fever.

We initiated a quality improvement (QI) project to develop and implement a comprehensive testing algorithm for critically ill children with new onset of fever or clinical instability, referred to as the "PICU Fever Algorithm".

Aims: Specific QI goals were to reduce blood culture rates to prior baseline, maintain respiratory culture (ie, endotracheal culture) rates, and reduce urine culture rates by 20%. Broader goals were to support judicious testing practices and encourage broader diagnostic considerations for patients with fever.

Objective

The objective of this study is to describe the algorithm development, implementation process and impact on testing practices.

Methods

Study design and setting: A mixed-methods study at a quaternary children's hospital including all PICU and pediatric cardiac (PCICU) patients ages <25 years.

Guideline Development: Occurred July 2019-June 2020 based on existing evidence and local stakeholder input. Stakeholders included critical care and infectious diseases, as well as surgeons, oncologists, neonatologist, cardiac intensive care, vascular-access, a human factor engineer. Algorithm revised based on feedback. Most recent February 2022 version is presented (Figure 1).

Implementation: Began July 2020. Shared with all ICU staff via email, meetings, paper copies, intranet access, in-person education, candy and raffle incentives.

Primary outcome: Monthly blood culture, respiratory culture, urine culture and urinalysis rates per 1,000 ICU patient-days were monitored with statistical process control U- charts. Incident rate ratios (IRR) were calculated comparing 24-month baseline period and 18 month post-implementation period. **updated data from abstract that referred to analysis of 12 months pre- and post- implementation.*

Safety Surveys: Electronic surveys of attending and fellow physicians were conducted via Qualtrics for one year post-implementation. Survey asked about patient safety concerns during the preceding week. Qualitative feedback was grouped thematically.

References

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3. Woods-Hill C et al. JAMA Pediatr. 2017 Feb 1;171(2):157-164
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5. Booth LD, et al. Pediatr Qual Saf. 2021 Aug 26;6(5):e463

Results

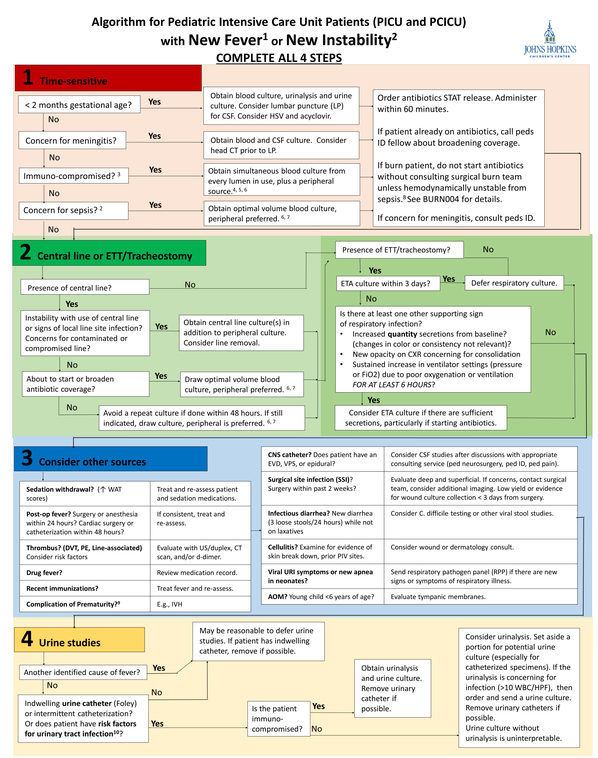

Figure 1. Algorithm for PICU and PCICU patients with new fever or instability. Front and Back sides displayed.

This is not an exhaustive list of devices or sources of fever. Please evaluate patient on individual basis and consider both risk factors for infections and non-infectious diagnoses.

Definitions

[1]New fever/hypothermia: multiple measurements taken 1 hour apart
- For neonates <2 months gestational age: Hyperthermia 38 C x1, hypothermia <36C x2 or increased need for temperature support
- For immunocompetent: 38.3 C x2, 38.5 C x1, or <36 C x2
- For immunocompromised: 38 C x2 or 38.3 C x1 or <36 Cx2
- New/first fever is at least 48 hours since last fever.

[2]New Instability or sepsis: rigors, hypothermia, hypotension (absolute or relative hypotension in patient on anti-hypertensive medications), use of vasoactive medications, tachycardia, mental status changes, poor perfusion, glucose instability, worsening organ dysfunction (lactemia, acute kidney injury, metabolic acidosis), abnormal WBC, new apnea/bradycardia or concern for NEC/SIP in neonates.

[3]Immunocompromised: immunocompromised patients may have masked signs of sepsis, particularly patients on > 1 mg/kg/day steroids, induction chemotherapy for HLH, induction or reduction therapy for Burkitt Lymphoma.

[4]Differential time-to-positivity is a useful way to distinguish catheter-related blood-stream infections from bacteremia unrelated to central line care. To be valid, equal volumes of blood must be obtained simultaneously from each lumen and a peripheral source and inoculated in the same culture media. Do not let difficulty obtaining peripheral blood cultures delay initiation of appropriate antibiotics (standard is <60 min from neutropenic fever to broad-spectrum coverage).

[5] Consider blood cultures from central line lumens and peripherally to distinguish line infections from bacteremia and to inform possible salvage of the central line. If considering catheter salvage, re-culture every lumen daily until negative.

[6] See blood culture volume for pediatric patients in HPO.

[7] After two unsuccessful peripheral attempts, attempt an arterial puncture sample. If unable to obtain an arterial sample via arterial puncture, obtain blood culture via central line. If unable to obtain central line culture, may consider changing the patient's arterial line set up and then obtaining an adequate specimen via arterial line. The arterial line should be the last option for blood sampling.

[8] Burn patients may have inflammatory response due to burns/debridement/grafting procedures. Antibiotics should only be used when absolutely needed (i.e. septic shock or identified infections). Antibiotics should be reviewed with PICU attending, surgical burn attending, and following ID team.

[9] Consider the differential for instability in premature neonates such as IVH, widened PDA, or RDS.

[10] Examples of UTI risk factors: structurally abnormal urinary tract, high grade hydronephrosis, neurogenic bladder

Abbreviations

LP- lumbar puncture; CSF: cerebrospinal fluid; ETT: endotracheal tube; ETA: endotracheal aspirate, WAT: withdrawal assessment tool; PE: pulmonary embolism; DVT: deep vein thrombosis; EVD: external ventricular drain; VPS: ventriculoperitoneal shunt; AOM: acute otitis media; UTI: urinary tract infection; RPP: respiratory pathogen panel CNS: central nervous system; NEC: necrotizing enterocolitis; SIP: spontaneous intestinal perforation; IVH: intraventricular hemorrhage; PDA: patent ductus arteriosus; RDS: Respiratory distress syndrome of the newborn

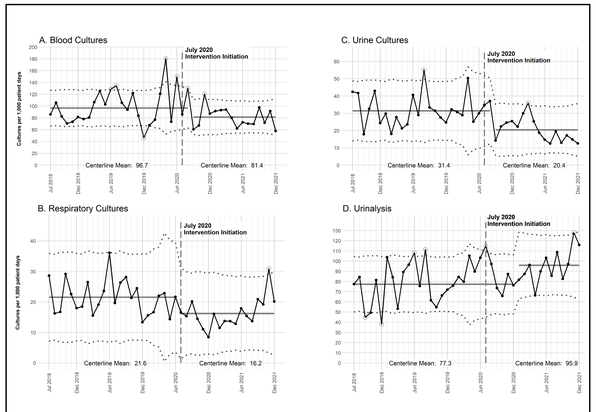

Figure 2. Statistical process control U-chart of testing rates per 1,000 ICU patient-days.

Table 1. Incident rate ratio (IRR) of testing rates per 1,000 ICU patient-days before and after introduction of the algorithm.

Test	Pre	Post	IRR	95% CI	% change
Blood cultures	96.7	82.9	0.86	0.80 – 0.91	- 14%
Respiratory cultures	21.6	16.2	0.74	0.63- 0.86	- 26%
Urine cultures	31.4	21.5	0.69	0.60-0.78	- 31%
Urinalysis	77.3	92.0	1.19	1.11-1.28	+ 19%

PICU physician safety surveys and feedback

- 46 of 108 (43%) safety survey invitations were completed by physicians on service in the preceding week
- 39 (85%) reporting having used the algorithm during the prior service week
- 0 reported an individual patient safety concern
- 2 (4%) provided constructive feedback
- 28 (61%) felt the algorithm improved patient care.

Table 2. Physician comments provided in survey grouped thematically.

Theme	Example comment
Judicious or deliberate testing practices	"It helped me not forget anything, but also prevented me from over tested when no clinical changes had occurred."
Reduced cognitive bias/expanded diagnostic differential	"It helped us broaden our differential and consider what else might be the origin of the fever."
Enhanced team communication (shared mental models)	"Assists with type of cultures to obtain and clinical decision making, particularly with respect to naming concern for sepsis."
Reported barriers or constructive feedback	"Well...we tried to use it, but other services 'insisted' on cultures when the algorithm stated they were not needed…"

Conclusions

- Implementation of this guideline was associated with a reduction in blood, respiratory and urine cultures, and an anticipated rise in screening urinalysis.
- There was no patient harm reported by PICU attending and fellow physicians, though this may not capture events not reported. Patient specific outcomes will need to be considered in larger and multicenter settings to validate these early single center findings.
- Although a large undertaking, the algorithm was well-received and achieved targeted goals.
- Overall, findings support that this comprehensive PICU fever algorithm based on evidence based practices supported judicious testing by avoiding testing over-use and promoting diagnostic differentials in critically ill children.

Acknowledgements

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