TRANSPORT DISPATCH

Section on Transport Medicine
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Welcome to the Operational and Quality Section of

Safety Is a Team Sport: Protecting Specialty Air Medical Teams

Terry Palmer

Air medical transport is never routine, but for specialty teams supporting neonatal, pediatric, and critically ill adult patients, the stakes are uniquely high. These missions combine time-sensitive clinical care with complex operational environments, often at night, in marginal weather, or under pressure to launch quickly. In this setting, safety is not a single decision or checklist, it is the result of how teams prepare, communicate, and support one another across the entire mission.

For neonatal and pediatric transport teams in particular, safety extends far beyond the aircraft itself. Patient fragility, equipment complexity, and limited physiological reserve demand an added layer of vigilance. The way aviation crews, clinicians, and dispatchers work together can directly influence both patient outcomes and crew well-being.

Safety Begins Before the Call

Many of the most important safety decisions in air medical transport occur long before patient contact. Dispatch information, weather assessments, aircraft availability, crew readiness, and destination planning all shape the risk profile of a mission.

For specialty teams, early decision-making is especially critical. Neonatal transports often involve extended preparation times, specialized equipment, and coordination with referring and receiving facilities. When launch decisions are rushed or information is incomplete, clinical teams may feel pressure to adapt in real time, increasing cognitive load during already demanding missions.

A shared understanding of operational risk helps reduce this pressure. When medical teams understand aviation constraints, and aviation crews understand clinical priorities, decisions become collaborative rather than transactional. This shared mental model strengthens trust and supports safer outcomes for everyone involved.

Training the Whole Team, Not Just Individual Roles

Air medical safety improves when training extends beyond individual disciplines. While clinical skills, flight operations, and dispatch procedures are often trained separately, real-world missions require these roles to function as an integrated team.

Joint briefings, tabletop discussions, and multidisciplinary case reviews help close this gap. For neonatal and pediatric teams, these conversations are particularly

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valuable when discussing equipment limitations, power requirements, loading configurations, temperature management, and contingency planning for patient deterioration during transport.

When teams train together, they develop a better understanding of each other's priorities and constraints. This reduces misunderstandings during high-workload situations and reinforces the idea that safety is a shared responsibility, not the burden of any single role.

Communication Under Pressure

Specialty air medical missions are characterized by high cognitive demand. Clinical teams are managing fragile patients while navigating noise, vibration, limited space, and evolving conditions. In these environments, communication must be clear, respectful, and continuous.

Authority gradients, time pressure, and task saturation can all interfere with effective communication. Teams that openly encourage questions, clarify assumptions, and normalize speaking up are better positioned to identify emerging risks before they escalate.

For neonatal and pediatric transports, where small changes in patient status can have significant consequences, this communication discipline is essential. Clear dialogue between clinicians, pilots, and dispatch helps ensure that operational decisions support clinical needs, and that clinical priorities do not unintentionally increase operational risk.

Learning From Experience and Institutional Knowledge

Policies and procedures provide structure, but experience provides context. Specialty teams benefit greatly from learning environments that value operational and clinical experience, especially when that experience is shared openly.

Post-mission debriefs, safety reviews, and case discussions allow teams to reflect on what went well and what could be improved. For neonatal and pediatric programs, these discussions often reveal subtle system issues related to equipment readiness, staffing models, communication pathways, or transport timing.

Mentorship also plays an important role. Experienced clinicians and crew members help newer team members recognize weak signals, anticipate challenges, and develop judgment that cannot be taught through protocols alone. This transfer of knowledge strengthens safety culture and supports long-term program resilience.

Dispatch as a Clinical Safety Partner

Dispatch is often the first point of contact in an air medical mission and serves as a critical safety partner throughout the transport process. For specialty teams, dispatchers play an essential role in gathering accurate information, coordinating resources, and supporting conservative decision-making.

Effective dispatch support reduces pressure on clinical and aviation crews by providing timely updates, realistic expectations, and clear communication. When dispatch is empowered to prioritize safety over speed, teams are better able to focus on patient care without feeling compelled to accept unnecessary risk.

Recognizing dispatch as an integral part of the care team reinforces the idea that patient safety is influenced by every link in the operational chain.

Safety as a Living System

Safety in air medical transport is not a static achievement, it is a living system that requires continuous attention. Training, reporting, quality improvement, and psychological safety all contribute to an environment where teams feel supported in making prudent decisions.

For neonatal and pediatric specialty teams, this support is especially important. The emotional weight of caring for vulnerable patients can amplify stress and fatigue. Programs that prioritize crew well-being, encourage open reporting, and respond constructively to safety concerns are better positioned to sustain both performance and morale.

Protecting the Teams Who Protect Patients
Air medical transport exists to provide critical care when and where it is needed most. That mission depends on the safety and readiness of the teams who carry it out. For specialty teams serving neonatal, pediatric, and critically ill patients, safety is not an abstract concept, it is woven into every decision, conversation, and action.

By strengthening collaboration, communication, and shared understanding across clinical, aviation, and dispatch roles, air medical programs can better protect both patients and the professionals who care for them. In the end, protecting patients begins with protecting the teams entrusted with their transport.

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camts
Commission on Accreditation of Medical Transport Systems

Preparing for Accreditation

Jan Eichel, MBA, CFRN, FAASTN, Executive Director

We understand many reasons **why** programs aim for accreditation, but today's article explains the process of **how** a program gets accredited. CAMTS (Commission on Accreditation of Medical Transport Systems) accreditation is a structured, multi-step process that typically takes 6-12 months to prepare for and complete. Below is a practical, phased timeline you can customize based on your organization's size and readiness. It's divided into a roughly 9–12-month plan, highlighting key milestones, activities, and typical durations. Adjust it as needed for your staff capacity and CAMTS site visit windows.

Note: CAMTS standards emphasize patient safety, quality improvement, clinical governance, line-item documentation, and demonstrated compliance through policies, procedures, and data.

Phase 0 — Preparation and gap analysis (1–2 months)

- Secure leadership sponsorship and assign a CAMTS coordinator.
    - Tip: Explicitly designate a scheduling owner who can coordinate teams and deadlines.
- Obtain CAMTS Standards Manual (current edition). Free download @ www.camts.org or www.camtsglobal.org (outside North America).
- Perform a comprehensive self-assessment (gap analysis) against CAMTS standards covering Clinical, Operational, Airworthiness/Technical, and Safety chapters, along with governance and data reporting.
- Create a CAMTS project plan with milestones, owners, and accountable departments.
- Establish a quality and safety committee.
- Gather baseline data: incident reports, flight/transport logs, medical records, dispatch data, PPE/crew qualifications, and equipment maintenance records.
- Create a gap list and plan corrective actions; prioritize based on risk and impact.

Phase 1 — Document development and policy alignment (2–4 months)

- **Submit your initial application at CAMTS:** www.camts.org/apply-for-accreditation
- You will receive the list of required attachments and the Program Information Folder (PIF). You have one year to complete and return the PIF.
- Policy and Procedure Review and Update:
    - Clinical care protocols and scope of service.
    - Airway management, pharmacology, sedation, transfusion, pain control, and pediatric considerations (as applicable to scope).
    - Documentation standards (electronic medical records, run sheets, handoffs).
    - Dispatch/communications policies.
    - Safety and risk management policies (hazard analyses, sentinel events, near-misses).
    - Equipment qualification, maintenance, calibration, and traceability.

    - Quality improvement (QI) plan, root cause analysis (RCA) processes, and performance improvement initiatives.
- Governance and leadership:
    - Define medical director and governance structure.
    - Credentialing and privileging procedures for clinicians and staff.
- Training and competency:
    - Orientation, recurrent training schedules, skills checklists, CME/training records.
- Data collection framework:
    - Define metrics, dashboards, and data collection methods for CAMTS domains.
- Begin compiling the necessary CAMTS documents.
    - Policies and procedures, organizational charts, job descriptions, training rosters, and vendor agreements.

Phase 2 — Data capture, performance improvement, and mock assessment (2–3 months)

- Gather and prepare data for CAMTS domains:
    - Clinical outcomes, adverse events, complication rates, 24/7 coverage metrics, and response times.
    - Equipment status, maintenance logs, crash/rescue events.
- Implement or refine QI projects:
    - Complete at least one formal improvement project with measurable metrics and RCA process, typically related to airway management or similar areas.
- Conduct internal audits and "mock CAMTS" readiness reviews.
    - Use CAMTS scoring methodology to identify strength/weakness areas.
    - Prepare evidence packets and organize all documentation.
- Training and drills:
    - Conduct tabletop or live drills focused on post-accident plans and evacuation plans.
- Gap closure:
    - Assign owners to address each gap by specific deadlines.
    - Update the CAMTS evidence binder with completed actions.

Phase 3 — Final policy consolidation and evidence compilation (1–2 months)

- Make sure all necessary CAMTS documents are up-to-date, easily accessible, and correctly versioned.
- Upload required list of documents to CAMTS PIF.
    - Organizational overview, governance, clinical policies, QC/QI records, training records, equipment maintenance, incident reporting, risk management, patient safety initiatives, and data dashboards.
- Pre-site visit readiness:
    - Perform a final internal review with key departments.
    - Verify leadership's 24/7 availability during the site visit window.
- Final mock survey (optional):
    - Have a cross-functional team walk through a simulated CAMTS survey, including anticipated questions and document requests.

Phase 4 — Application and site-visit preparation (1–3 months; disposition dependent on CAMTS cycle)

- Submit the CAMTS application and fees according to the CAMTS schedule. (Fees vary depending on the number of bases and vehicle assets.)
- CAMTS reviewer assignment and intake:
    - Arrange team for the site visit (lead surveyor, safety officer, medical director, QA lead, operations leader).
- Site visit readiness:
    - Schedule the site visit dates with CAMTS.
    - Ensure access to all required areas (clinical zones, flight/clinical hangars, dispatch, communications centers, quality/records offices).
- Documentation delivery:
    - Have copies or access ready for surveyors: policies, SOPs, training records, QA/QI reports, incident logs, corrective action plans, maintenance records, credentialing files, and medical equipment logs.

Phase 5 — Site survey and response (Typically 2 days on-site)

- During the site visit:
  - CAMTS surveyors will interview staff, take pictures, review clinical training records, and inspect equipment.
  - Be prepared to demonstrate real-time QA/QI processes, incident reporting, and corrective actions.
- After the site visit:
  - CAMTS will no longer accept new documentation or input
- Await CAMTS decision:
  - CAMTS Board meets quarterly. You will be advised of the meeting date.

Phase 6 — Post-accreditation actions and maintenance (ongoing)

- If accredited:
  - Reply to the board about any weaknesses within the usual 3-6 month period.
  - Schedule regular internal reviews as needed; ensure ongoing compliance and continuous quality improvement.
  - Keep the CAMTS binder updated with changes, re-audits, or progress on any conditions.
- If not accredited or "provisional:"
  - Take corrective actions to fix non-conformities within six months.
  - Respond within CAMTS guidelines when ready; address all identified gaps before resubmission. The board will review your program.

Practical tips to accelerate the process

- Begin with leadership support and assign a dedicated CAMTS leader early.
- Create a well-organized digital evidence repository with clear indexing and version control.
- Align all departments around shared data definitions (e.g., what constitutes a "critical adverse event").
- Schedule internal audits and mock surveys well in advance of the actual site visit.
- Engage external consultants with CAMTS if necessary, but make sure you retain internal ownership of the process.
- Create a realistic timeline with buffers for reviewer questions or data requests.

Sample 9–12 month roadmap (high-level)

- Months 1–2: Preparation, gap analysis, assign CAMTS lead, start policy review.
- Months 3–4: Policy alignment, governance, training, initial data collection.
- Months 5–6: Deep data capture, QI projects, mock assessments, gap closure.
- Months 7–8: Finalize documents, evidence binder assembly, readiness drill.
- Months 9–12: Submit application, schedule/site visit, respond to any requests, site visit, await decision.

Contact the office to register for the webinar, *Preparing for Accreditation*. Four hour recording that covers all areas of becoming accredited.

Email-- admin@camts.org

Congratulations Cohen Children's Pediatric-Neonatal Transport Team!

We're proud to recognize **Cohen Children's Pediatric-Neonatal Transport Team** for earning CAMTS Accreditation. This achievement reflects their unwavering commitment to:

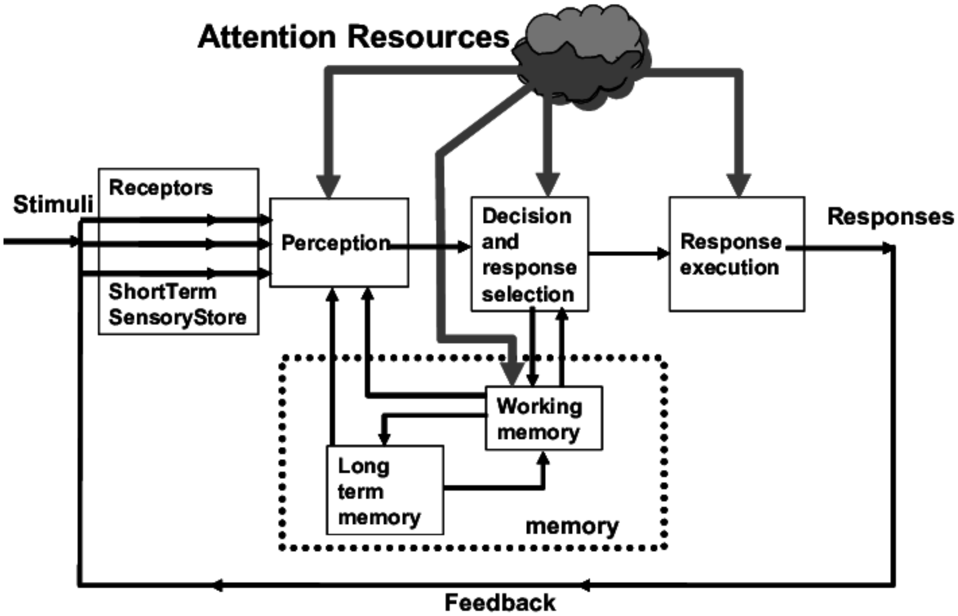
- Patient care standards
- Crew qualifications
- Safety protocols
- Continuous quality improvement

Your dedication ensures the highest level of care for every patient—especially our smallest and most vulnerable.

An Introduction to Human Factors Engineering in Critical Care Transport (Part 2 of 2)

Hamilton P. Schwartz, MD, MEd, FAAP, FACEP, on behalf of GAMUT

In *Transport Dispatch*'s last issue, we covered cognitive ergonomics – the first of the human factors triad. **This time, we tackle the implications of physical and macroergonomics**. Before we do that, look at what I found to refresh our understanding of cognitive ergonomics. I find the diagram below one of the most helpful visuals of the interplay of concepts we discussed in the last issue. The critical takeaway is that we only have so much attention to go around (see the cloud at the top of the image). As system designers, we must be careful about how many tasks we simultaneously ask our team members to do, remember, and think about at any given time. There may not be sufficient brainpower to go around, even in the most capable people.



Wickens, C. D. (1992). *Engineering Psychology and Human Performance* (2nd ed.). HarperCollins.

Physical Ergonomics: Bodies in Motion, Literally

Transport clinicians routinely work in spaces that violate almost every ergonomic principle. That's why we all have bad backs! The keys to optimizing physical ergonomics emphasize anthropometry (measurements and proportions of the human body), biomechanics, posture, reach, and injury prevention. Each of these is put to the test during transport.

1. **Anthropometry and Reach**: Aircraft and ambulance interiors often fall outside the **recommended functional reach envelope**. Examples include:

- Trying to adjust a ventilator mounted behind the stretcher
- Over-the-head airway management while kneeling sideways
- Lifting and rotating infants in isolettes placed too high or too low

2. **Biomechanics and Vibration**: Biomechanical efficiency deteriorates with awkward posture, static holding, or repetitive micro-corrections. Vehicle vibration further reduces fine motor ability and increases fatigue.

3. **Cumulative and Acute Injuries**: Cumulative injuries occur from both static postures and repetitive motions. Acute injuries result from awkward lifting, bending, or patient movement. Unfortunately, transport crews face both simultaneously, whether it's lifting from uneven ground, crouching in the cabin, or securing equipment in flight.

4. **Equipment Layout and Link Analysis**: Physical ergonomics includes link analysis, mapping how people move between tools. In transport, link analysis often reveals excessive reaching for suction, poor placement of medication bags, necessary gear stored behind other gear, and monitor cables and IV tubing that cross workspaces. These "small" design mismatches may not seem like big deals, but they compound during critical tasks.

Engineering Implications for Transport

Key physical redesign strategies include:

- **Layout aircraft/ambulances for the 5th–95th percentile provider range**
- **Use link analysis** to reposition high-frequency tools within easy reach
- **Modify equipment mounting** to enable direct sightlines to monitors or vents
- **Reduce static posture** through adjustable seating or repositionable equipment
- **Adopt lifting and packaging workflows that reduce rotation and asymmetry**

These are ergonomic interventions, but they are also safety interventions!

Macroergonomics: The System Around the Team

If cognitive ergonomics concerns minds and physical ergonomics concerns bodies, macroergonomics concerns the system that surrounds both. Macroergonomics is the **integration and optimization of people and technical systems**. It involves the interactions of people, tasks, technology, environment, organization, and the external world. Sounds like a lot; I know.
A useful tool for breaking down and understanding the system is SEIPS (Systems Engineering Initiative for Patient Safety [Holden RJ, Carayon P. *BMJ Qual Saf* 2021;30:901–910. doi:10.1136/bmjqs-2020-012538]). It breaks the system into the following:

- **People** (clinicians, pilots, dispatchers)
- **Tasks** (assessment, packaging, documentation)
- **Technology** (pumps, vents, radios)
- **Environment** (cabin layout, lighting, noise)
- **Organization** (fatigue policy, training, staffing)
- **External environment** (weather, regulations, referral hospital behavior)

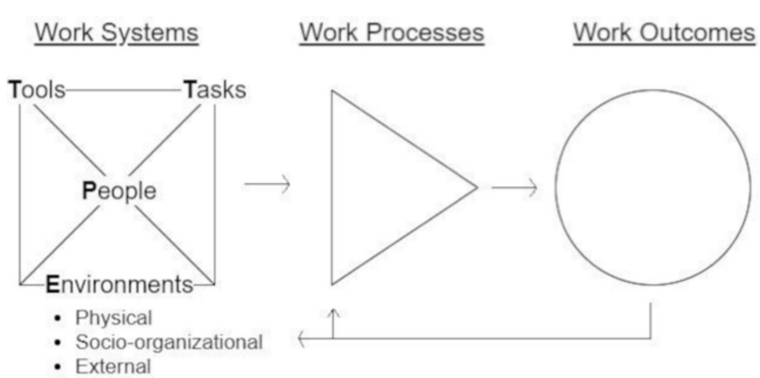


Figure 1 SEIPS 101 simplified model. Work systems are depicted by a square, evoking the iconic 'connected boxes' visualisation of person-centred systems: an interconnected set of factors with people in the centre. Work systems shape and produce work processes, depicted as a triangle to convey flow from left-to-right. The end results are work outcomes, drawn as a circle for the 'O' in outcome. Arrows represent causal feedback loops. Several details are omitted for simplicity. SEIPS, Systems Engineering Initiative for Patient Safety. Holden RJ, Carayon P. BMJ QUAL SAF 2021;30:901–910. doi:10.1136/bmjqs-2020-012538

In transport, adverse events almost always emerge from interactions across multiple SEIPS components. For example, a medication error during flight might involve the following:

- Poor labeling (technology)
- Vibration (environment)
- Fatigue (person)
- Work shortcuts (task)
- Lack of standardization across aircraft (organization)

No single point of blame. The system, not the clinician, needs redesign.

Engineering Implications for Transport

Macroergonomic improvement strategies include:

- **Fatigue management policies** based on duty hours and workload
- **Standardizing equipment across vehicles** to reduce cognitive and physical variability
- **Aligning dispatch, medical control physicians, and clinical teams under shared mental models**
- **Integrating human factors review into QI and incident analysis**
- **Using SEIPS proactively** during protocol and equipment redesign

You can't "train out" a bad system. But you can design a better one.

Usability: If It's Hard to Use, It's Designed Wrong

Poor design is a latent failure; one that sits quietly until the wrong moment. Transport teams encounter usability issues constantly. Examples include: touchscreens that don't register gloved taps, interfaces that require excessive scrolling or nested menus, medication labels unreadable under dimmed or red lighting, pump displays too dim in sunlight, and radios with non-intuitive menu structures.

Nielsen's 10 heuristics provide a rapid, structured method for evaluating any transport device—ventilators, pumps, defibrillators, cardiac monitors, incubators, radios, or packaging systems. The now-classic list was published in 1994 in Jakob Nielsen's book *Usability Inspection Methods*. Using Nielsen's heuristics, teams can systematically evaluate transport equipment for:

1. Visibility of System Status

The system should always keep users informed about what's going on through clear, immediate feedback. Examples include loading indicators, alarms that indicate what triggered them, and confirmation lights.

2. Match Between System and the Real World

Use language, concepts, and workflows familiar to the user—not internal technical jargon. "Blood pressure" instead of "NIBP," icons that resemble real-world objects.

3. User Control and Freedom

Users need a clear "exit" or undo path, especially when they take an action by mistake. Cancel, back, reset, stop infusion, and revert settings, for example.

4. Consistency and Standards

Similar things should look and behave similarly. Follow industry and platform conventions. Green = start, red = stop; alarms follow standard tones; layout stays consistent.

5. Error Prevention

The design should prevent errors from happening or make them very hard to make. Forcing functions, confirmation steps for high-risk actions, and incompatible connectors for things that shouldn't ever be connected.

6. Recognition Rather Than Recall

Users shouldn't have to remember information from one screen or step to another. Menus, labels, icons, prefilled defaults, on-screen reminders, smart phrases.

7. Flexibility and Efficiency of Use
Design should serve both novices and experts. Offer shortcuts for advanced users. Quick-start modes, favorites lists, customizable presets.

8. Aesthetic and Minimalist Design
Keep interfaces clean. Show only the information needed at that moment. Avoid cluttered screens, reduce noise, streamline critical displays.

9. Help Users Recognize, Diagnose, and Recover From Errors
Error messages must be clear, human-readable, and actionable. "Pump occlusion: check tubing" vs. "E5646-4a."

10. Help and Documentation
Even with good design, users sometimes need help. Documentation must be easy to access and focused on essential tasks. Quick guides, laminated cards, embedded help, step-by-step prompts.

Work System Analysis, RCA, and FMEA: The Tools that Fix Things

Although we can't cover them thoroughly in this article, here is an overview of the types of tools human factors specialists use to make improvements.

Work System Analysis is a structured method for understanding how people, tasks, tools, technology, environment, and organizational factors interact within a real workflow. By observing the process as it actually occurs (not just how it's imagined), the team identifies "misfits," places where the demands of the system exceed human capabilities or where components don't align well. These misfits reveal system weaknesses and latent hazards. The goal is to redesign the work system to support human performance better, reduce errors, and improve safety and efficiency. We might not label it "Work System Analysis," but when you watch a process and interview staff to create a detailed process map, you're doing a form of work system analysis.

Root Cause Analysis (RCA) is a structured, retrospective process used to understand why an adverse event or near miss occurred. Instead of focusing on who made a mistake, RCA examines how system factors such as workflow, communication, equipment, environment, and policies created conditions where the error was possible. By tracing the event back through contributing factors to the underlying system causes, the team can design stronger, sustainable fixes that prevent similar events from happening again. RCAs often trigger major quality improvement projects.

Failure Modes and Effects Analysis (FMEA) is a proactive method for identifying how a process, device, or system could fail before harm occurs. The team maps out each step, asks "What could go wrong?", and then evaluates each potential failure mode for its severity, likelihood, and detectability. By prioritizing the highest-risk failures, the team can redesign the process or equipment to prevent errors, reduce the chance of harm, and strengthen safety before implementing the system in real-world use. This is also a tool commonly used in quality improvement projects for realizing testable interventions.

Conclusion – Design for the Realities of Transport

Critical care transport pushes human performance to its limits. Vibration, noise, fatigue, spatial constraints, and cognitive load are not flaws in the people doing the work; they are characteristics of the system in which they operate. Human factors engineering provides tools to identify where systems don't accommodate people, to redesign environments, workflows, and technology, to reduce errors, to enhance efficiency, to safeguard clinician well-being, and to deliver safer care in one of healthcare's most demanding settings. Transport clinicians don't need to be superhuman (though most of you are ☺); they need systems designed for humans.

Stay quality, my friends!

Opinion Piece: What Does Safety Really Mean? (Part 2 of 3)

Thomas J. Maxian, National President, Ground and Support Operations, Global Medical Response, Ken Thom, VP of Fleet, Tim Schroeder, Chief Engineer

Equipment

Building a culture of safety extends beyond leadership, people, and process. The endeavor must include safe equipment that serves the needs of caregivers and patients alike. Recognizing this fundamental truth, we decided to build our own ambulances at GMR. Though daunting, this bold initiative enabled us to design and build an ambulance with safety and ease of use as our primary objectives.

Building an ambulance from the ground up created the unique opportunity to embrace the virtues and utility of existing design elements while simultaneously challenging the status quo. Our sole guidepost was to ensure that the ambulance we built both enabled *and* supported the behaviors and practices necessary to optimize caregiver and patient safety. To that end, we assembled multiple focus groups at our manufacturing facility in Mineral Wells, Texas, comprising GMR EMTs, paramedics, nurses, and union leaders.

Ensuring that the voices of the would-be users of our ambulance were heard at the design table yielded two great benefits. First, we were able to gather incredible insights and innumerable design ideas born of the real-life experiences of our providers. Second, we earned critical provider buy-in regarding the behaviors necessary to maximize the safety benefits of our ambulance redesign. During each focus group, we witnessed "aha" moments when participants realized that providers *must* adopt the right behaviors to use the safety features and benefits inherent in our GMR ambulances.

One of the key safety factors that drives ambulance design and construction is crash testing. Such testing necessitates the evaluation of an array of factors, including two key safety components: (1) the strength of the mounts used to secure equipment, caregiver seats, seatbelts, patient cots, etc.; and (2) the structural integrity of the ambulance itself. We undertook 14 crash tests with our prototype ambulance at forces up to 26Gs, or 26 times the standard acceleration that results from the earth's gravitational pull. Our mounts and ambulances met or exceeded the national safety standards governing ambulance crash testing. While we were thrilled with how our ambulances performed in rigorous crash testing, we knew for sure that our design and construction breakthroughs would be rendered nearly meaningless if our providers failed to wear seatbelts.

Recognizing and explicitly acknowledging this reality, our design team narrowed its focus to a relatively simple concept: maximize the amount of time our providers can remain seated wearing seatbelts. To breathe life into that concept we leveraged our focus groups to understand provider behaviors and the realities that drive those behaviors. Analysis of our focus group data revealed that, while in the ambulance's patient compartment, our providers spend about 90 percent of their time seated in the forwardmost position on the squad bench. Our data also showed that providers prefer to sit sideways, facing patients, to enable good eye contact and meaningful interaction, and to provide access to patients' heads, torsos, and arms to facilitate good patient care. While this position optimized patient care, it simultaneously jeopardized provider safety because providers were forced to unbuckle and move to reach medical equipment and disposable supplies, or to adjust lighting or temperature. We also discovered that the practice of unbuckling, moving, and re-buckling becomes so tedious and cumbersome that providers simply remain unbuckled. Remaining unbuckled had become so normalized that the practice quickly evolved into a seemingly unavoidable occupational risk.

To bring about what would amount to a tectonic shift in philosophy and halt the routine practice of providers remaining unbelted, we needed to bring equipment, supplies, and the patient closer to our providers. With that in mind, our design engineers reimagined and revolutionized the layout of the patient compartment. We systematically relocated lighting and temperature controls, along with many other critical items, placing them within providers' direct reach while still seated and securely belted. We utilized wall-mounted, crash-stable pouches to enable easy access to frequently used supplies. We also positioned the cardiac monitor at the front of the squad bench and oriented it so caregivers could see the screen and access controls without unbuckling or moving. We similarly relocated the trash can, sharps container, ALS work tray, and power outlets to enable easy access while safely restrained. Further, we mounted our stretcher in the center of the ambulance to ensure that caregivers could reach patients while remaining in their seatbelts. And finally, we secured every relocated item in crash-tested, crash-stable mounts to ensure it would remain securely affixed in the event of a collision. The result is that our providers can now remain seated and secure while continuing to provide optimal care to patients.

In addition to addressing major safety issues, our ambulance design team addressed several "little things" that, when improved, significantly enhance the experiences of providers and patients. To ease the burden of climbing in and out of the ambulance and to reduce the hazard of awkwardly stretching to make that large step, we added automatic fold-out stairs to the curbside doorway, significantly reducing step heights. To reduce the incidence of provider head strikes, we made two additional design modifications. We raised the height of the door openings and likewise increased the internal ambulance "box" height to six feet. Those changes have reduced head strikes on doorways and on the safety grab rail that runs from front to back along the ceiling in the patient compartment.

Finally, our design team addressed an issue that has plagued patients and providers since the first ambulance turned a wheel more than a century ago—comfort in extreme temperature conditions. Our engineers designed a high-performance HVAC system with vents that run the length of the patient compartment along the ceiling. The team also specially engineered and built a highly insulated "box" composed of an array of materials designed to maintain patient compartment temperatures better. The robust HVAC system and "box" composition create a force multiplier, enabling our teams in the South to stay cooler in extreme heat and our teams in the North to stay warmer in extreme cold. The specially designed materials that comprise the shell of our "box" also reduce its weight. The lighter "box" reduces chassis stress and improves performance and handling, creating an additional benefit beyond its ability to maintain comfortable temperatures better.

Through a collaborative design process that included engineers, providers, fleet teams, and other subject-matter experts, we built an ambulance tailored to the needs of our patients and providers. Our GMR ambulance builds upon the designs of predecessor ambulances, retaining many of their features while adding the enhancements that our caregivers recommended. By blending the virtues of past ambulance designs with the fresh ideas of today's providers, we have been able to improve the safety, effectiveness, and efficiency of the ambulance. Most importantly, our ambulance design supports GMR's long-term commitment to patient and provider safety and provides another way to link safety to culture.

Welcome to the Clinical and Scientific Section of TRANSPORT DISPATCH

Pediatric Kinetic Sand Aspiration: A Novel Airway Challenge Requiring Coordinated Critical Care Transport and ECMO

Jordon C. Mitzelfelt, MD[1,2], Casey McMillan, BSN, CCRN, TCRN[3], Sarah D. Brunner, MD[1,2], Jenna O. Miller, MD[1,2], Jennifer Flint, MD[1,2]

Editor's Summary

This case reports the first kinetic sand aspiration event in a pediatric patient. It also illustrates the need for timely communication, thoughtful planning, and expert critical care during pediatric interfacility transport for patients requiring definitive care at quaternary referral centers. The authors state it best in the closing summary: "*This case demonstrates how proactive planning, clear communication, specialized teams, and advanced medical support are all vital to successful patient outcomes.*"

Nice work!
Michael H Stroud, MD, FAAP

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Dr. Mitzelfelt and Dr. Flint designed the study, drafted the manuscript and reviewed the manuscript. Dr. Flint also collected data. Ms. McMillan reviewed the manuscript. Dr. Miller drafted and reviewed the manuscript. Dr. Bruner drafted and reviewed the manuscript.

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Abstract

This case centers on the critical decision-making and communication between Pediatric Critical Care Transport (PCCT) and the Medical Control Physician (MCP) in managing a 7-month-old infant with life-threatening respiratory failure due to kinetic sand aspiration. Decisions made by PCCT permitted rapid inter-facility transfer, and proactive communication between the transport team and MCP allowed the quaternary care hospital to mobilize a multidisciplinary team, expediting urgent initiation of extracorporeal membrane oxygenation (ECMO) to safely facilitate bronchoscopy for kinetic sand removal. The efficiency of definitive care allowed the patient to be successfully decannulated from ECMO in less than 24 hours with a full recovery back to respiratory and neurologic baseline.

Introduction

Pediatric sand aspiration events, while rare, most often occur secondary to near drowning and accidental burial in sand and can result in a wide range of clinical outcomes from full recovery to fatality.[1,2] Only two reports exist in the medical literature describing the use of extracorporeal membrane oxygenation (ECMO) as a bridge for definitive management of sand aspiration.[3,4] Aspiration of kinetic sand which is a mixture of ultra-fine grain sand and dimethicone, a type of silicone that gives the sand its moldable property, has not previously been described in the literature.[5] Patient outcomes in case reports of kinetic sand ingestion range from uncomplicated recovery to intussusception and bowel obstruction requiring medical intervention.[5,6]

The receiving hospital is a free-standing pediatric quaternary center located in a metropolitan area. It is the only Level I pediatric trauma center in the region and offers services such as solid organ transplant, advanced critical care that includes the use of extracorporeal supports such as ECMO, continuous renal replacement therapy, and apheresis, and access to more than 40 pediatric subspecialties. The hospital's Pediatric Critical Care Transport (PCCT) team has an annual volume of 5,800 interfacility pediatric, neonatal, and maternal fetal patient transports via ground, rotor wing, and fix wing serving a multi-state region. The specialized pediatric transport team consists of one pediatric critical care nurse, one pediatric respiratory therapist (RT), and one emergency medical technician (EMT). Pediatric critical care fellows rotate with the team as clinical observers as part of their required training, but they are not dispatched for specific patient acuity. The team is equipped for secondary transport of patients already stabilized on ECMO. The team has an established rapid launch process to mobilize a team quickly that is triggered by high acuity words such as cardiac arrest, impending respiratory failure, etc. Referring providers communicate directly to the Medical Control Physician (MCP) through the transfer center. The MCP is a pediatric intensivist who is on clinical duty in the hospital.

In addition to the unique clinical scenario described here, the progression of this case from a rural community hospital to a quaternary care hospital highlights how critical high-stakes decisions shared between the PCCT and the MCP can greatly impact the time course to definitive care and ultimately the clinical outcome in challenging situations.

Clinical Presentation

Initial Presentation at Rural Emergency Department

An 8kg, 7-month-old male was transported to a rural Emergency Department (ED) following an unwitnessed ingestion and suspected aspiration of kinetic sand. In the ED, the infant required emergent intubation and epinephrine for a critical desaturation event (SpO_2 40%) with bradycardia. An intraosseous (IO) line was the only point of access. Inclement weather precluded rotor-wing transport to the quaternary center, so the ED provider opted to utilize local ground EMS for transfer to the nearest facility with pediatric critical care support, a local 15-bed Pediatric Intensive Care Unit (PICU). This PICU was located 65 miles from the rural ED and served as the midpoint to the quaternary pediatric center (an additional 65 miles away).

Local PICU and Transport Logistics

The physician at the local PICU contacted the quaternary PICU MCP at 15:23, prior to the patient's arrival, indicating they would perform initial stabilization, including central line placement, prior to formal request for transfer. Though this clinical situation would have triggered our rapid launch process, the physician specifically requested that we wait to dispatch a team. Recognizing the high-risk nature of the situation, the MCP and PCCT proactively dispatched a team to a staging area located 10 minutes from the local PICU. In anticipation of severe respiratory compromise, in addition to the transport ventilator (Hamilton T1, Hamilton Medical AG, Bonaduz, Switzerland) the MCP authorized the addition of specialized equipment including nitric oxide and a high-frequency ventilator (Bronchotron® ventilator, Percussionaire Corp., Sandpoint, ID, USA) designed for pediatric transport. The PCCT was dispatched at 15:39. PCCT remained at the staging area, utilizing the downtime for detailed team communication and contingency planning, while awaiting a formal transfer request from the referring physician.

Pre-transport Assessment and Intra-transport Management

Upon PCCT arrival at the local PICU (19:05), the patient was sedated with fentanyl and dexmedetomidine, under chemical neuromuscular blockade, and had right neck central venous access. Initial assessment revealed poor bilateral air entry and severe respiratory acidosis (pH 7.05, pCO_2 93 mmHg, SpO_2 90% on FiO_2 0.90). The Oxygen Saturation Index (OSI) was 25. Ventilator settings were pressure control (PC) of 35 and a peak end expiratory pressure (PEEP) of 8, generating tidal volumes of 30–35 mL (~4mL/kg) and an end-tidal CO_2 ($EtCO_2$) reading of 124 mmHg.
In-line suctioning failed to clear the sand particles or improve ventilation. The patient failed multiple trials on the transport ventilator. Adjustments to the I-time, respiratory rate, PC and PEEP resulted in immediate worsening of $EtCO_2$ reading and oxygen saturations. A trial of Airway Pressure Release Ventilation (APRV) was unsuccessful, yielding the same results. Effective ventilation was achieved only through manual bagging with a flow-inflating bag using a prolonged inspiratory time and high peak inspiratory pressures (PIP) of 40–50 cmH_2O.

Ventilation and oxygenation difficulties were communicated to the MCP. The PCCT and MCP agreed that the safest and most timely course of action was to manually bag the patient and immediately transport to the quaternary PICU for increased medical support and definitive management. During transport, the patient remained sedated and under neuromuscular blockade while being manually ventilated with a flow-inflating bag. The ventilation strategy included the use of a long I-time with a lower respiratory rate while maintaining a PEEP of at least 10 with PIPs of 40–50 cmH_2O. Oxygen saturations were maintained >85%, monitored via pulse oximetry. A repeat VBG at 20:48 confirmed ongoing but stable respiratory acidosis (pH 7.03, pCO_2 88 mmHg), which was relayed to the quaternary center to ensure ECMO standby.

Quaternary PICU and ECMO Support

Upon arrival at the quaternary center (21:29), a multidisciplinary team (PICU, Otolaryngology, Pulmonology, and ECMO) was at the bedside. Initial suctioning yielded thick, gritty remnants of kinetic sand. During attempted rigid bronchoscopy, the patient experienced profound desaturation and cardiovascular instability. Due to the inability to maintain oxygenation during airway clearance, veno-venous (VV) ECMO was initiated. The surgical team used the existing right neck central line and the Seldinger technique to insert a 15-French Crescent™ (MC3 Cardiopulmonary, Dexter, MI; Medtronic, Minneapolis, MN) cannula at the bedside in the PICU.

Once stabilized on ECMO, Otolaryngology and Pulmonology performed exhaustive bronchoscopy with numerous passes and a total procedure time of over two hours. Kinetic sand was visualized from the distal trachea through the entire tracheobronchial tree to the third branch point. The airway was cleared using a total of 500 mL of saline lavage in small aliquots until all obstructive plugs were removed, and remaining sand particles were minimal.

Outcome

Following airway clearance, pulmonary compliance improved rapidly. The patient was decannulated after an ECMO run of 17 hours and 21 minutes. He was transitioned to a general ward on day 3 and discharged home on day 6 at his neurologic and respiratory baseline.

Figure 1: Timeline of Events

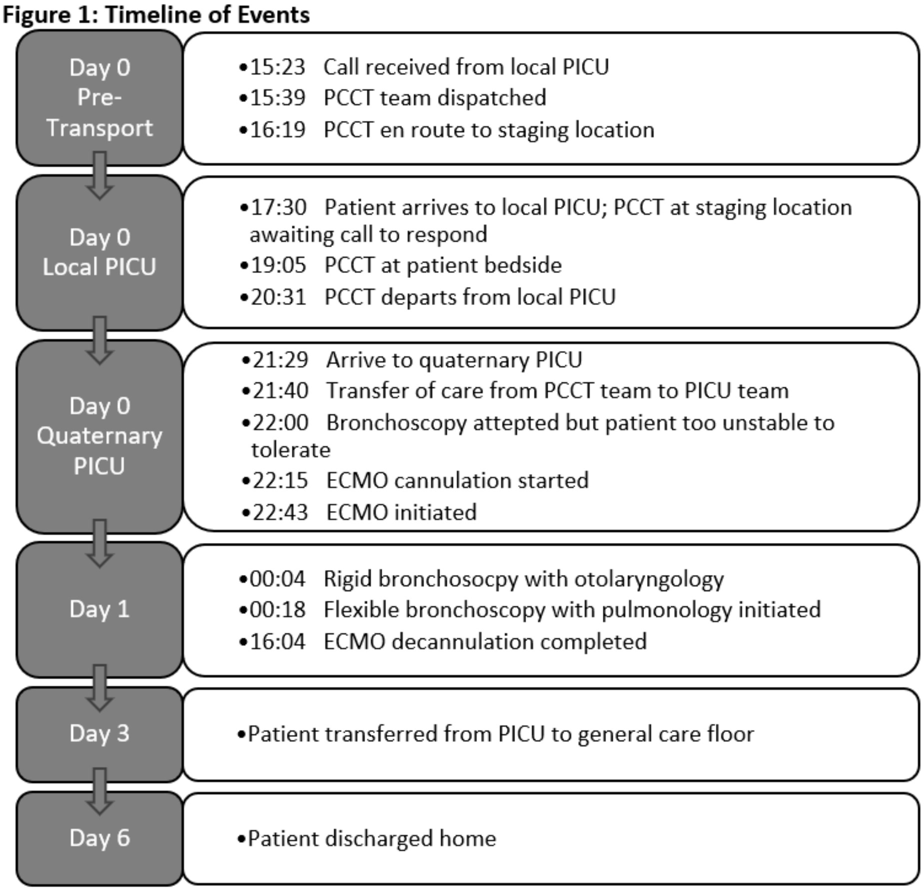
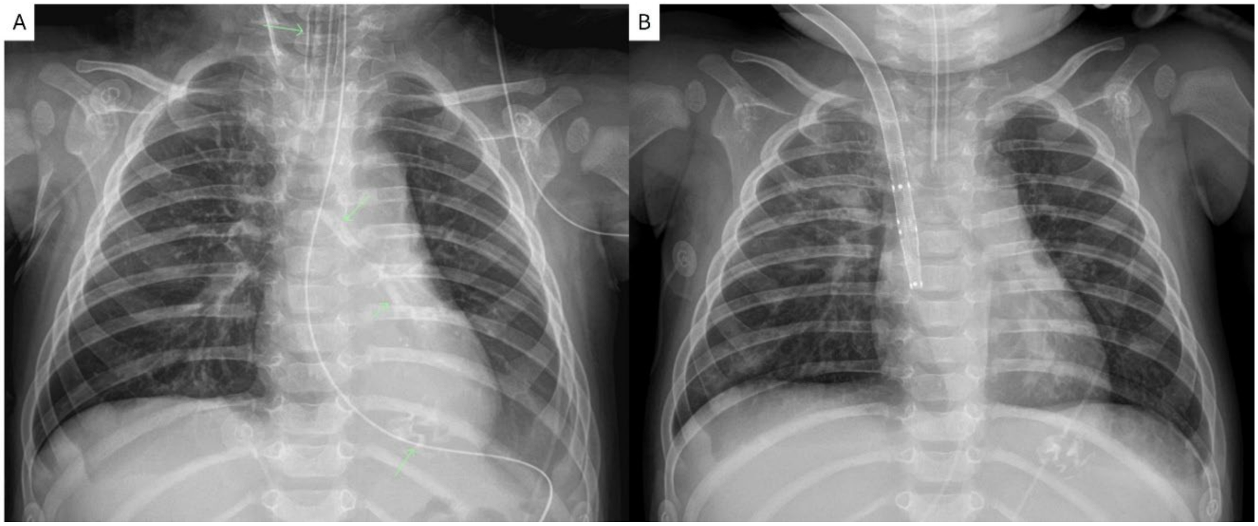


Image 1: X-ray Before and After Bronchoscopy



A. Before bronchoscopy; B. After bronchoscopy

Discussion

This report presents a unique clinical scenario involving the aspiration of kinetic sand in a pediatric patient, an event not described in the medical literature. This case highlights how proactive communication between the referring provider, PCCT, and receiving facility can mobilize resources for timely care and optimize patient outcomes. While few case reports exist detailing the management of general sand aspiration with bronchoscopy, none specifically involve kinetic sand aspiration.[1,7,8] Furthermore, in the two existing reports of pediatric sand aspiration where ECMO was used as a bridge to airway clearance, ECMO support was required for three days.[3,4] The clinical course underscores the spectrum of severity associated with aspiration events, where the degree of aspirated material and resulting inflammation significantly varies.[3] Our patient achieved a favorable outcome, being successfully decannulated from ECMO within 24 hours. This rapid recovery may be attributable to the inherent variability of aspiration injuries, and to the early mobilization of specialized resources, which accelerated definitive care and the prompt removal of sand particulates.

Several critical decision points optimized the clinical timeline. The referring physician notified our team before the patient arrived at their facility; however, the request was unique in that they did not formally request our team, nor did they desire patient contact until the patient was stabilized. Nonetheless, prompt communication allowed the PCCT and MCP to mobilize and plan early. Although clinical information was limited during the initial call, proactive planning enabled the team to include high-frequency ventilation and nitric oxide in anticipation of severe respiratory failure.

The decision to dispatch immediately and stage the PCCT at a designated location near the referring facility was a pivotal operational choice. This proactive staging allowed the team to mitigate the 65-mile geographical delay without intruding upon the referring facility's initial request to stabilize the patient prior to activating our team. Had dispatch from the quaternary center been delayed until the second call from the local PICU, the time to bedside would have been extended over an hour, potentially affecting this patient's outcome.

While double-transfers are generally minimized, the advantage of presenting to the local PICU first allowed the patient to be under the care of a pediatric-trained intensivist sooner. The local PICU served as a vital stabilization bridge when weather precluded a direct 130-mile flight to the quaternary center.

Furthermore, this case illustrates the crucial balance between bedside stabilization at a referral facility and prioritizing rapid transit for definitive care. When multiple attempts to transition to the transport ventilator failed, the MCP and PCCT agreed that the next best option was to manually bag the patient, which allowed the team to maintain current level of oxygenation and ventilation without significant patient decompensation, and immediately transport to the quaternary center. Prolonging attempts at the local PICU would have only delayed presentation to the necessary subspecialty teams at the quaternary care center.

In summary, the successful management of this patient's kinetic sand aspiration was achievable due to early communication, implementation of tactics that decreased time to definitive management with bronchoscopy, and the use of ECMO as a bridge to facilitate stability during complex airway clearance. This case demonstrates how proactive planning, clear communication, specialized teams, and advanced medical support are all vital to successful patient outcomes.

References

1. Arun Babu T, Ananthakrishnan S. Unusual presentation of sand aspiration in a 14-mo-old child. *Indian J Pediatr*. Sep 2013;80(9):786-8. doi:10.1007/s12098-012-0913-7
2. Kettner M, Ramsthaler F, Horlebein B, Schmidt PH. Fatal outcome of a sand aspiration. *Int J Legal Med*. Nov 2008;122(6):499-502. doi:10.1007/s00414-008-0252-4
3. Baqais KA, Mahoney M, Tobler K, Hui A, Noseworthy M. Pediatric sand aspiration managed using bronchoscopy and extracorporeal membrane oxygenation. *Can Respir J*. Sep-Oct 2015;22(5):261-2. doi:10.1155/2015/278368
4. Isaac A, Kawaguchi A, Garros D, Guerra GG, El-Hakim H. Sand aspiration in a child: Extracorporeal membrane oxygenation (ECMO) as a new management tool. *Journal of Pediatric Surgery Case Reports*. 2013;1(9):273-276. doi:10.1016/j.epsc.2013.07.016
5. Ahuja K, Muhammad U, Ahuja K, Haricharan R, Patel P. Kinetic sand! A tale of sandy times. *JPGN Rep*. Nov 2024;5(4):480-482. doi:10.1002/jpr3.12123
6. Turner A, Sico R, Seifarth FG. Ingestion of kinetic sand leading to intussusception and bowel obstruction in a child: a case report. *AME Case Rep*. 2024;8:13. doi:10.21037/acr-23-37
7. Kapur N, Slater A, McEniery J, Greer ML, Masters IB, Chang AB. Therapeutic bronchoscopy in a child with sand aspiration and respiratory failure from near drowning--case report and literature review. *Pediatr Pulmonol*. Oct 2009;44(10):1043-7. doi:10.1002/ppul.21088
8. Efron PA, Beierle EA. Pediatric sand aspiration: case report and literature review. *Pediatr Surg Int*. Jul 2003;19(5):409-12. doi:10.1007/s00383-003-1021-6

Effect of a Novel Neonatal Resuscitation and Transport Training Course on EMS Providers' Confidence and Skills: A Prospective Pre-Post Study

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Editor's Summary

What is already known on this topic?
Out-of-hospital births are high-risk, low-frequency events for EMS providers, and prior literature suggests that many prehospital clinicians have limited neonatal resuscitation training, experience, and confidence. EMS-specific neonatal resuscitation curricula remain relatively sparse.

What question does this study address?
Does the ABCs of Newborn Resuscitation and Transport (NRT) course improve paramedic students' self-reported confidence, knowledge, and selected neonatal resuscitation skills after training?

What does this study add to the literature?
In this single-arm pre-post study, participants showed significant gains in all measured confidence domains, knowledge test scores improved from 70.2% to 87.3%, and 79.8% of tested learners improved their positive pressure ventilation performance in simulation. The article also highlights the potential value of a simulation-rich, EMS-specific neonatal curriculum.

How is this relevant to our clinical practice?
For transport and EMS educators, this paper supports offering focused neonatal resuscitation training for providers who may rarely encounter out-of-hospital deliveries but must perform well when they do. *The findings are encouraging, though they should be interpreted as evidence of improved confidence and simulated performance rather than definitive proof that the course alone improves real-world clinical outcomes.*

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Dr. Oddi designed the study, collected data, performed data analysis, drafted the manuscript and reviewed the manuscript. Dr. Jensen designed the study, collected data, performed data analysis, and reviewed the manuscript. Mr. Francomano designed the study, collected data, and reviewed the manuscript.

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Abstract

Background: Out-of-hospital births (OOHB) are increasing in prevalence, but emergency medical services (EMS) providers often lack adequate neonatal resuscitation training.

Objective: To evaluate the impact of the "ABCs of NRT—Easy as 1, 2, 3" course on paramedic students' confidence and skills in neonatal resuscitation and transport.

Methods: In this prospective pre-post study conducted from 2021-2025, 202 paramedic students from a regional EMS training program completed matched pre- and post-intervention confidence surveys, knowledge assessments, and skill evaluations related to neonatal resuscitation. The course included didactic instruction, hands-on skills training, and high-fidelity simulation. Statistical analyses included Wilcoxon signed-rank tests, paired t-tests, and McNemar's test.

Results: Significant improvements were observed in all confidence domains ($p < 0.001$), knowledge test scores (mean increase from **70.2% to 87.3%; Cohen's** ***d*** **= 1.89**), and practical skills (79.8% improved positive pressure ventilation [PPV] performance; $p < 0.001$).

Conclusion: The ABCs of NRT course was associated with improvements in paramedic students' self-reported confidence, knowledge scores, and selected neonatal resuscitation skills. Given the absence of a control group, reliance in part on self-

reported outcomes, and incomplete follow-up testing, future controlled studies are needed to better define the course's true effect.

Introduction

Out-of-hospital births (OOHB) represent a significant clinical challenge for emergency medical services, with Clark County experiencing approximately 2.3% of all births occurring outside traditional hospital settings, consistent with national trends ranging from 1.5% to 3.2%.[2,5] Research indicates that neonates born in out-of-hospital settings are at increased risk for adverse outcomes compared to those born in hospitals. A 2022 national study found that out-of-hospital births in the United States were associated with a higher risk of neonatal morbidity and mortality, including increased rates of low Apgar scores and need for advanced resuscitation.[7] While national data on NICU admission rates by birth setting are limited, recent evidence suggests that out-of-hospital births are linked to higher rates of infant complications requiring hospital transfer and advanced care compared to planned hospital deliveries.[7] Local data from Sunrise Children's Hospital further emphasize this clinical concern, demonstrating that at least half of out-of-hospital births in the region require NICU admission, reflecting the elevated acuity of these cases in our service area.[6] These statistics underscore the critical importance of advanced neonatal resuscitation training for paramedic students, as they are often the first medical professionals to encounter these high-risk scenarios. Evidence-based neonatal resuscitation protocols, such as those outlined in the Neonatal Resuscitation Program,[8] provide a framework for emergency delivery situations, making comprehensive training programs essential for prehospital care providers.

Despite the critical need for timely and skilled resuscitation in these settings, EMS paramedics in the United States are not required to maintain current certification in the Neonatal Resuscitation Program (NRP), and most receive limited or outdated neonatal training during their education.[3,4] The unique physiology of the transitioning newborn, the specific interventions required, and the low frequency but high stakes of these events all contribute to low confidence and high anxiety among EMS providers tasked with newborn resuscitation and transport.[4] Surveys of prehospital providers in both the United States and internationally have consistently identified gaps in neonatal resuscitation knowledge, infrequent exposure, and a desire for more targeted educational opportunities.[4]

Simulation-based and hands-on training have demonstrated efficacy in improving provider confidence and skills in high-acuity, low-frequency scenarios, including neonatal resuscitation.[9] However, few curricula are specifically tailored to the EMS environment, which poses unique logistical, environmental, and resource-related challenges for newborn care in the field.[4] To address this persistent gap, a multidisciplinary team developed the ABCs of Newborn Resuscitation and Transport (NRT)—Easy as 1, 2, 3, an evidence-informed, simulation-rich, and EMS-specific training course. The goal of this study was to evaluate the impact of the NRT course on paramedic students' confidence, knowledge, and skills in newborn resuscitation and transport, with the hypothesis that targeted training would lead to significant improvements in all domains.

Methods

This prospective, single-arm, pre-post interventional study was conducted from April 2021 through April 2025 to evaluate the impact of a novel newborn resuscitation and transport (NRT) training course—ABCs of NRT-Easy as 1, 2, 3—on paramedic students' confidence, knowledge, and practical skills in neonatal resuscitation. The course was developed by a multidisciplinary team including physicians, nurses, and respiratory therapists to address the unique challenges faced by EMS providers during out-of-hospital births, which are increasing in frequency and are associated with higher neonatal morbidity and mortality. This study was reviewed and approved by Sunrise Medical Center Institutional Review Board and deemed exempt as educational quality improvement.

Participants included paramedic students enrolled in regional EMS training programs who attended scheduled NRT training sessions. Over the five-year period, 243 students participated in the course, with 202 completing both pre- and post-course confidence surveys and included in the primary analysis. A subset of 121 students completed paired knowledge assessments, and 104 students participated in practical skills testing involving positive pressure ventilation (PPV) on a high-fidelity neonatal manikin, excluding those with manikin malfunctions.

The ABCs of NRT course curriculum consisted of a one-hour didactic presentation covering the physiology of the transitioning newborn, common resuscitation scenarios, and safe transport principles; 1.5 hours of hands-on skill stations focusing on airway management, bag-mask ventilation, advanced airway placement including laryngeal mask airway (LMA), chest compressions, vascular access, medication administration, and environmental considerations; followed by two hours of high-fidelity simulation scenarios with debriefing designed to integrate and reinforce these skills in realistic neonatal resuscitation and transport situations.

Participants completed self-assessment surveys immediately before and after the course, rating their confidence on a 5-point Likert scale (1 = not confident to 5 = very confident) across key neonatal resuscitation domains: initial steps, providing PPV, endotracheal intubation, LMA placement, and chest compressions. Knowledge was assessed using a 20-item multiple-choice test adapted from the Neonatal Resuscitation Program (NRP) with emphasis on out-of-hospital care principles, administered pre- and post-course. Practical skills were evaluated by measuring improvement, defined as achieving adequate chest rise, appropriate rate [40-60 breaths/min], and proper seal as assessed by trained evaluators using a standardized checklist, in effective PPV delivery during a three-minute manikin-based simulation.

Statistical analyses were performed using paired tests appropriate for the data type. Wilcoxon signed-rank tests compared pre- and post-course confidence scores given their ordinal nature. Paired t-tests evaluated changes in knowledge test scores assuming approximate normality. McNemar's test assessed the proportion of students who improved PPV skills. Descriptive statistics including means, standard deviations, and medians summarized the data. Statistical significance was set at $p < 0.05$. All analyses were conducted using standard statistical software packages.

Results

A total of 202 paramedic students completed both pre- and post-course confidence surveys after participating in the ABCs of Newborn Resuscitation and Transport (NRT) training from 2021 to 2025. Paired analyses demonstrated significant improvements in self-reported confidence across all evaluated neonatal resuscitation skills (Table 1). **Effect sizes ranged from large to very large (Cohen's *d* = 1.10 to 2.03), with the greatest improvements observed in endotracheal intubation (*d* = 2.03) and positive pressure ventilation (*d* = 1.72).**

Table 1. Pre- and Post-Course Confidence Scores (Likert 1–5) for Key Neonatal Resuscitation Skills

Skill	Pre Mean (SD)	Post Mean (SD)	Median Pre	Median Post	Wilcoxon Z	p-value	Cohen's *d*
Initial Steps	2.72 (1.00)	3.69 (0.69)	3.0	4.0	-11.9	<0.001	1.47
Providing PPV	2.57 (0.99)	3.74 (0.72)	3.0	4.0	-12.2	<0.001	1.72
Endotracheal Intubation	1.90 (0.91)	3.22 (0.76)	2.0	3.0	-12.4	<0.001	2.03
Placement of Laryngeal Mask	2.36 (1.07)	3.47 (0.83)	2.0	4.0	-12.0	<0.001	1.52
Chest Compressions	3.21 (1.06)	3.97 (0.76)	3.0	4.0	-10.8	<0.001	1.10

Note: All p-values <0.001. Cohen's *d* values indicate effect sizes, where $d > 0.8$ represents a large effect and $d > 1.2$ represents a very large effect.

All confidence domains showed statistically significant improvement after the course. Knowledge assessment was completed by 121 students, with mean test scores improving from **14.0 (SD 2.2)** pre-course to **17.5 (SD 1.6)** post-course (out of 20 points), corresponding to an increase from **70.2% to 87.3%** (paired t-test, **$t(120) = -18.55$**, $p < 0.001$, Cohen's d=1.89).

Practical skills in positive pressure ventilation (PPV) were evaluated for 104 students (after excluding cases of manikin malfunction). Of these, 83 (79.8%) demonstrated improvement in PPV performance during a three-minute simulation, with a significant difference by McNemar's test ($p < 0.001$). The remaining 21 (20.2%) did not show improvement.

Discussion

This prospective cohort study demonstrates that the ABCs of NRT-Easy as 1, 2, 3 course is effective in improving paramedic students' confidence, knowledge, and practical skills for newborn resuscitation and transport. Statistically significant improvements were observed in all domains of self-reported confidence, with the greatest gains in advanced airway management skills such as endotracheal intubation and laryngeal mask placement. Knowledge test scores also improved substantially, with a very large effect size (Cohen's d = 1.89) indicating robust practical impact beyond statistical significance. The majority of participants demonstrated enhanced proficiency in positive pressure ventilation, a critical neonatal resuscitation skill.

These findings align with previous reports that EMS providers frequently lack experience and confidence in neonatal resuscitation, particularly during out-of-hospital births, which are high-risk, low-frequency events associated with increased neonatal morbidity and mortality.[1,2,6,8] Prior research has identified a gap in standardized neonatal resuscitation training among prehospital providers, which this novel NRT curriculum directly addresses.[3,4] The improvement in confidence and skills is likely attributable to several features of the course: a focus on the unique physiology and needs of the transitioning newborn, structured hands-on practice with simulation, and targeted education on prehospital management and transport considerations. Notably, nearly 80% of students improved their PPV skills, suggesting effective translation of didactic and simulated learning into practical competency.

Several limitations of this study should be considered when interpreting these findings. First, the absence of a control group means that causality cannot be established. Without a comparison group of students who did not receive the NRT course, it is not possible to confirm that the course itself drove the observed improvements. Gains in knowledge and confidence may reflect other factors, such as independent study, increased motivation during the training period, or the Hawthorne effect, whereby participants perform better simply because they know they are being evaluated. Second, confidence data relied entirely on self-reported Likert-scale ratings, which are inherently susceptible to response bias. Students may feel social or academic pressure to report higher confidence after completing a training program, irrespective of actual skill acquisition, which could lead to an overestimation of the course's true impact on provider readiness. Third, the incomplete data across assessment types introduces the possibility of selection bias. Only 121 of 202 students (59.9%) completed paired knowledge assessments, and only 104 (51.5%) participated in practical skills testing. The further exclusion of cases due to manikin malfunction reduced the sample available for PPV skill evaluation. Students who completed all components may differ systematically from those who did not, meaning the results may not be fully representative of the entire cohort. Future studies should evaluate skill retention over time, incorporate a control group design, and correlate training outcomes with real-world clinical performance for transported newborns.

In summary, the ABCs of NRT course addresses a critical training gap for EMS providers and has demonstrated effectiveness in enhancing prehospital readiness for neonatal resuscitation and transport. Implementing similar curricula more broadly has the potential to improve outcomes for out-of-hospital births and other neonatal emergencies encountered by EMS.

Conclusion

This study demonstrates that paramedic students who completed the ABCs of NRT Easy as 1, 2, 3 course reported greater self-confidence in neonatal resuscitation skills for some period of time following training, and may show improvement in their ability to perform critical skills such as positive pressure ventilation. While these findings are encouraging, they should be interpreted cautiously given the absence of a control group and the reliance on self-reported confidence measures. Future studies incorporating a randomized or controlled design are needed to confirm that skill acquisition is attributable to the course itself rather than other factors. Such research should also examine long-term skill retention and explore the relationship between training outcomes and real-world clinical performance during out-of-hospital birth responses.

References

1. Cheyney M, Bovbjerg M, Everson C, Gordon W, Hannibal D, Vedam S. Outcomes of care for 16,924 planned home births in the United States: the Midwives Alliance of North America Statistics Project, 2004 to 2009. *J Midwifery Womens Health*. 2014;59(1):17-27. doi:10.1111/jmwh.12172.
2. Gregory ECW, Osterman MJK, Valenzuela CP. Changes in home births by race and Hispanic origin and state of residence of mother: United States, 2019–2021. Natl Vital Stat Rep. 2022;71(8):1-10.

3. Hill MG, Flanagan B, Mills B, Hansen S, Hopper L. Paramedic training, experience, and confidence with out-of-hospital childbirth (OOHB) in Australia. Australas Emerg Care. 2023;26(2):119-125. doi:10.1016/j.auec.2022.08.008
4. Huynh TK, Smith JD, Neth M, et al. Virtual neonatal resuscitation curriculum for emergency medical services (EMS) to improve out-of-hospital newborn care. Prehosp Emerg Care. 2025;30(1):17-23. doi:10.1080/10903127.2025.2450074
5. MacDorman MF, Declercq E. Trends and characteristics of United States out-of-hospital births 2004–2017. *Birth*. 2019;46(2):279-288. doi:10.1111/birt.12420.
6. Sunrise Children's Hospital. Neonatal intensive care unit admission data for out-of-hospital births, Clark County, Nevada, 2020-2024. Unpublished institutional data.
7. Way S, Oza-Frank R, Khuu D. Out-of-hospital births and infant mortality in the United States: effect measure modification by rural maternal residence. *Paediatric and Perinatal Epidemiology*. 2022;36(3):399-411. doi:10.1111/ppe.12862
8. Weiner GM, Zaichkin J, eds. Textbook of Neonatal Resuscitation. 8th ed. American Academy of Pediatrics; 2021.
9. Xu C, Zheng Y, Luo Y, et al. Potential benefits and challenges of simulation-based neonatal resuscitation training: a simulation-based competition study. *Front Pediatr*. 2025;13:1534321. doi:10.3389/fped.2025.1534321

Use of Less Invasive Respiratory Support During Transport

Donald M. Null, MD, FAAP[1,2]

Editor's Summary

What is already known on this topic?
Noninvasive and less invasive respiratory support strategies such as CPAP, HHFNC, NIPPV, and high-frequency nasal ventilation are widely used in neonatal care, but transport decisions remain challenging because patient stability can change quickly and transport-specific evidence is limited.

What question does this article address?
Which neonatal patients may be appropriate candidates for transport on less invasive respiratory support, and what physiologic, operational, and safety factors should transport teams consider when deciding whether to proceed without intubation?

What does this article add to the literature?
This article provides a practical transport-focused framework for evaluating CPAP, HHFNC, NIPPV, and HFNV, including modality-specific advantages and limitations, contraindications, pre-transport assessment priorities, and illustrative clinical scenarios. It emphasizes trend-based decision-making, team comfort with the modality, and the importance of transport-specific protocols and outcome tracking.

How is this relevant to our clinical practice?
This article speaks directly to a common transport dilemma: when is it safe to move a fragile neonate on non-intubated support, and when is it safer to secure the airway first? It gives transport teams a thoughtful framework for those decisions while reinforcing that clinical course, transport duration, and team experience matter as much as the device itself.

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Dr. Null designed the study, collected data, performed data analysis, collected data, drafted the manuscript and reviewed the manuscript.

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Introduction and Terminology

"Invasive" implies an intrusion into the body. By that strict definition, many modalities we routinely label as non-invasive, including nasal CPAP (NCPAP), humidified high-flow nasal cannula (HHFNC), nasal intermittent positive pressure ventilation (NIPPV), and high-frequency nasal ventilation (HFNV), are not truly non-invasive. Devices placed in the nares can appear invasive to families and may undermine confidence if terminology is poorly chosen.

When counseling parents, it is preferable to refer to therapies by their specific names (CPAP, HFNC, etc.) rather than using the blanket term non-invasive. Families should be reassured that these strategies support breathing without placing a tube in the trachea, and explanations should focus on how the therapy helps their infant breathe more effectively.

Currently Available Modalities

- NCPAP – Nasal Continuous Positive Airway Pressure
- HHFNC – Humidified High-Flow Nasal Cannula
- NIPPV / NIMV – Nasal CPAP with intermittent positive pressure breaths
- HFNCPAP / HFNV – Bulky nasal interface delivering high-frequency pulsations

The following sections review the physiology, advantages, disadvantages, and potential complications of each modality, with a focus on transport considerations.

Nasal Continuous Positive Airway Pressure (CPAP)

CPAP improves functional residual capacity by maintaining continuous airway pressure, preventing alveolar derecruitment, improving lung compliance, and reducing airway resistance, thereby decreasing the work of breathing. Its advantages include consistent and predictable pressure delivery, effective prevention of derecruitment, and favorable performance in patients with low lung compliance. CPAP is commonly used in extremely preterm infants, including those less than 28 weeks' gestation; however, evidence directly comparing noninvasive modalities in this population is limited, and practice is largely guided by physiologic principles and expert clinical experience rather than definitive comparative trials. However, CPAP requires a bulky, easily dislodged interface that does not actively recruit collapsed lung units, may interfere with parental bonding and skin-to-skin care, and requires skilled nursing support. In practice, both nurses and parents often prefer HHFNC. Complications include air leak syndromes, nasal trauma, abdominal distension, and potential deterioration of lung function.

Humidified High-Flow Nasal Cannula (HHFNC)

HHFNC provides variable nasopharyngeal pressure and facilitates washout of anatomic dead space. As flow increases, respiratory rate often decreases, although the effect on work of breathing varies by patient characteristics and clinical context. Pharyngeal pressure increases in a nonlinear and highly variable manner as flow is increased and is influenced by patient weight, cannula size, mouth position, and leak. At flows of 4–8 L/min, reported pressures span a wide range, and individual patients may generate substantially higher or lower pressures than anticipated, complicating prediction of delivered distending pressure and weaning strategies. Advantages of HHFNC include ease of application, decreased nasal trauma, and strong preference by parents due to improved opportunities for bonding. HHFNC is also favored by nursing staff and is generally well tolerated by neonates. Disadvantages include reduced effectiveness in patients with poor lung compliance, lack of active lung recruitment, increased risk of air leak if cannula size is inappropriate, and unpredictable airway pressure, particularly in infants weighing less than 1000 grams. Additionally, clinicians may lose track of the effective delivered FiO_2. Complications include air leak syndromes such as pneumothorax, pneumomediastinum, pneumocephalus, and pneumoorbitis, often related to improper cannula sizing.

CPAP with Assisted Breaths (NIPPV)

NIPPV shares the physiologic benefits of CPAP while adding intermittent assisted breaths. These additional breaths promote lung recruitment, improve compliance, decrease work of breathing, and may reduce the frequency of apnea. Advantages mirror those of CPAP, with the added benefit of improved minute ventilation and enhanced oxygenation through more uniform lung inflation. Synchronized NIPPV appears to offer physiologic advantages over non-synchronized modes, particularly with respect to reducing work of breathing and respiratory failure; however, available data are insufficient to support definitive conclusions. Non-synchronized NIPPV may still confer benefit compared with CPAP alone in selected populations. Disadvantages are similar to CPAP, with the additional theoretical concern that during apnea, delivered volumes may preferentially enter the stomach rather than the lungs. Complications are also similar to CPAP, with an increased risk of air leak when peak inspiratory pressures exceed 20 cm H_2O.

High-Frequency Nasal Ventilation (HFNV)

HFNV improves lung expansion and can rapidly enhance oxygenation, even in patients with poor lung compliance. High-frequency pulsations augment ventilation and facilitate gas exchange. This modality is particularly effective for recruiting poorly compliant lungs and can be useful in patients with apnea while minimizing gastric insufflation. In select cases, small endotracheal tubes (2.0, 2.5, or 3.0 mm) can be placed in a single nostril to facilitate delivery. High-frequency ventilation requires a dedicated and costly device that not all teams may have access to. Other disadvantages include the need for specialized nasal prongs, such as Hudson CPAP prongs, and the requirement for highly skilled nursing and respiratory therapy support. During transport, HFNV necessitates advanced monitoring, including pre- and post-ductal oxygen saturation, invasive blood pressure, transcutaneous CO_2 (if available), and ready access to blood gas analysis. Complications include an increased risk of air leak if ventilator settings are not promptly adjusted as lung compliance improves. Lung overdistension may potentially lead to pulmonary hypertension, decreased blood pressure, and an increased risk of intraventricular hemorrhage.

General Contraindications to Transport on Less Invasive Support

- Congenital diaphragmatic hernia
- Bowel obstruction
- Necrotizing enterocolitis
- Gastroschisis or omphalocele
- Tracheoesophageal fistula

These conditions share a high risk of gastric insufflation, leading to impaired pulmonary mechanics, bowel compromise, or worsening pulmonary hypertension.

Additional Contraindications to Consider

- Pulmonary hypertension on inhaled nitric oxide without response
- Persistent respiratory distress despite high-level support (e.g., CPAP ≥8 cm H_2O, HFNC 7–8 L/min, NIPPV with rate >20 and PIP >20)
- Recurrent apnea requiring stimulation or bag-mask ventilation
- Sepsis with poor perfusion or cardiac output
- Significant acidosis (metabolic pH <7.2 with base deficit ≥10, or respiratory pH <7.25 with $PaCO_2$ >60)

The transport team should be ready to discuss safety concerns related to less invasive support with the referring institution and even decline the transport if an agreement cannot be reached.

Patients Who May Be Good Candidates for Transport on Less Invasive Support

- Chronic lung disease
- Acute respiratory distress with stability
- Stable on current support for >2 hours
- Chest radiograph showing adequate inflation without air leak
- FiO_2 <0.5 and stable or decreasing
- $PaCO_2$ <60 with pH >7.3 and stable
- Transport team comfortable with the selected modality

Pre-Transport Assessment of Patients Considered for Less Invasive Respiratory Support

A thorough assessment is essential for patients under consideration for transport with less invasive respiratory support. The physical examination should focus on respiratory rate, breath sounds, and the presence and severity of retractions. Particular attention should be paid to abdominal findings, particularly the position of the liver at the right costal margin. During transport or clinical deterioration, a liver edge that appears displaced inferiorly may indicate lung overdistension or the development of an air leak, such as pneumothorax. In contrast, a liver edge that appears higher than baseline may indicate loss of lung volume, in which case increasing CPAP or high-flow support may be beneficial.

Assessment should also include evaluation of how quickly and reliably the patient's oxygen saturation recovers after brief interruptions of noninvasive ventilatory support, such as during repositioning or equipment adjustments. The patient's overall stability should be observed during routine handling, physical examination, chest radiography, suctioning, and other necessary care activities. These observations provide important insight into how the patient is likely to tolerate the stresses of transport.

In addition, the anticipated type and duration of transport should be carefully considered, as longer transports or air transport may magnify physiologic instability. Prior to departure, patients should have a recent chest radiograph demonstrating acceptable lung inflation without evidence of air leak, as well as a blood gas confirming adequate ventilation and acid–base status.

Patient Scenarios

Case 1

A 30-week infant delivered for maternal preeclampsia (Apgars 6 and 8) was placed on CPAP in the delivery room and admitted to the newborn nursery on CPAP 6 cm H_2O with FiO_2 0.25 (SpO_2 95%). At two hours of age, the transport team found the infant on HFNC 6 L/min with FiO_2 0.3 (SpO_2 93%). Capillary blood gas showed pH 7.34, $PaCO_2$ 58 mm Hg, and PaO_2 40 mm Hg, with chest radiography demonstrating moderate lung expansion.

The patient was transitioned back to CPAP at 7 cm H_2O. Thirty minutes later, SpO_2 decreased to 90% with FiO_2 0.35, and repeat capillary blood gas showed worsening ventilation (pH 7.30, $PaCO_2$ 60 mm Hg, PaO_2 38 mm Hg). Transport was deferred due to increasing pressure and oxygen requirements. Further deterioration to FiO_2 0.5, SpO_2 88%, pH 7.25, $PaCO_2$ 65 mm Hg, and PaO_2 32 mm Hg was plausible, and earlier transport would likely have resulted in intubation en route. The key indicators of instability were worsening blood gases and increasing oxygen requirements, which suggest poor lung expansion likely worsened by the early transition to HFNC.

Case 2

A 28-week infant delivered after precipitous labor (Apgars 5 and 7) was placed on CPAP in the delivery room and transferred to the newborn nursery on CPAP 5 cm H_2O with FiO_2 0.6 (SpO_2 92%). The transport team arrived at 30 minutes of age and found the infant clinically stable. CPAP was increased to 6 cm H_2O, resulting in FiO_2 reduction to 0.55 with SpO_2 93%. Capillary blood gas showed pH 7.28, $PaCO_2$ 63 mm Hg, and PaO_2 32 mm Hg.

After intravenous access was established, chest radiography showed moderate lung expansion. CPAP was increased to 7 cm H_2O during line placement, with further improvement to FiO_2 0.45 and SpO_2 93%. Arterial blood gas showed pH 7.34, $PaCO_2$ 58 mm Hg, and PaO_2 72 mm Hg. Brief CPAP disconnection resulted in rapid recovery of oxygen saturation. Given the steady improvement in oxygen requirement, ventilation, and lung expansion, this patient was deemed appropriate for transport on CPAP.

Final Considerations

Transport teams must develop clear protocols for the use of less invasive respiratory support and systematically collect outcome data. Transport modality, duration, and stability trends are critical to just-in-time decision making. Transport physiology differs substantially from the NICU environment, a reality well understood by transport teams, but not always by referring clinicians. This article is intended as practical guidance grounded in available evidence, physiologic principles, and real-world transport experience. For several respiratory modalities and patient populations—particularly extremely preterm infants and transport-specific scenarios—high-quality comparative data remain limited. As a result, many recommendations reflect expert judgment rather than firm evidence-based standards. The approaches described here should be applied flexibly, with decisions guided by the patient's clinical trajectory, local resources, and the transport team's experience.

References

1. Liew Z, Fenton AC, Tooley J, et al. Physiological effects of high-flow nasal cannula in preterm infants. Arch Dis Child Fetal Neonatal Ed. 2020;105(F1):F87–F93.
2. Jeffreys E, Hunt KA, Harris C, et al. Diaphragm electromyography results at different high-flow nasal cannula flow rates. Eur J Pediatr. 2019;178:1237–1242.

3. Conte S, Profeta O, Scateni S, et al. Rapid systematic review shows that using a high-flow nasal cannula is inferior to nasal continuous positive airway pressure as first-line support in preterm neonates. Acta Paediatr.2018;107:1684–1696.
4. Manley BJ, Owen LS, Doyle LW, et al. High-flow nasal cannula in very preterm infants after extubation. N Engl J Med. 2013;369:1425–1433.
5. Hong H, Li X, Chen Y, et al. High-flow nasal cannula versus nasal continuous positive airway pressure for respiratory support in preterm infants: a meta-analysis of randomized controlled trials. J Matern Fetal Neonatal Med. 2019;32:2597–2604.
6. Lee WY, Choi EK, Kim H, et al. Risk factors for treatment failure of heated humidified high-flow nasal cannula as initial respiratory support in newborn infants with respiratory distress. Pediatrics. 2019;144(3):e20190904.
7. Yoder BA, Kirpalani H, eds. Noninvasive ventilation. Clin Perinatol. 2016;43(4).
8. Roberts CT, Hodgson KA. Nasal high-flow treatment in preterm infants. Mod Healthc Neonatal Perinatol.2019;3:15.
9. Eklund WM, Scott PA. High-flow nasal cannula practice patterns reported by neonatologists and neonatal nurse practitioners in the United States. Adv Neonatal Care. 2018;18(5):400–412.
10. Sivieri EM, Wolfson MR, Abbasi S. Pulmonary mechanics measurements by respiratory inductive plethysmography and esophageal manometry: methodology for infants on noninvasive respiratory support. J Neonatal Perinatal Med. 2019;12(2):149–159.
11. Fleeman N, Dundar Y, Dickson R, et al. Heated humidified high-flow nasal cannula for preterm infants: an updated systematic review and meta-analysis. Int J Technol Assess Health Care. 2019;35(4):298–306.
12. Null D, Crezee K, Bleak T. Noninvasive respiratory support during transportation. Clin Perinatol. 2016;43:741–754.
13. Ramanathan R, Biniwale M. Noninvasive ventilation. Crit Care Nurs Clin North Am. 2024;36(1):51–67.
14. Wang K, Yue G, Gao S, et al. Noninvasive high-frequency oscillatory ventilation versus nasal continuous positive airway pressure for preterm infants: a systematic review and meta-analysis. Arch Dis Child Fetal Neonatal Ed.2024;109:397–404.

Palliative Neonatal Transports to Home

Nikki Brown, MS, CRNP, NNP-BC[1,2]

Editor's Summary

What is already known on this topic?
Most neonatal transports are designed around escalation of care or transfer to lower-acuity settings, but a small and important number involve transport to home or hospice for end-of-life care. These transports require unusually high levels of planning, communication, and coordination across teams.

What question does this article address?
What practical elements should neonatal transport teams consider when planning and carrying out palliative neonatal transports to home?

What does this article add to the literature?
This article offers a clear operational framework for palliative neonatal transport, organized around who, what, where, when, why, and how. It highlights multidisciplinary planning, equipment and medication needs, home-site assessment, transport timelines, MOLST/POLST documentation, interpreter and spiritual support needs, and the importance of discussing billing and family preferences in advance.

How is this relevant to our clinical practice?
Many teams infrequently perform these transports, which is precisely why a framework like this is valuable. The article reminds us that excellence in transport medicine involves not only saving lives but also assisting infants and families in reaching home safely and compassionately when comfort is the priority.

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Neonatal transports are primarily focused on conditions that require emergent transport and escalation to intensive care, or non-emergent transport to rehabilitation facilities or less intensive care. There is, however, a growing subset of neonates that are being transported to hospice facilities, or to their family's home to receive hospice care. Although small in number, palliative neonatal transports require a great deal of planning and interdisciplinary coordination of care, therefore it is imperative that transport programs have guidelines in place to provide quality and timely service. Here I plan to describe some of the basic considerations for palliative neonatal transports to home.

Most neonatal intensive care units (NICUs) have some version of palliative care services, however, this is often tied to hospital-wide teams that primarily focus on adults and pain management. As is common in the neonatal world, NICUs have been required to adapt to meet the unique palliative care needs of infants and their families. Not only have there been limitations within NICUs, but historically hospice facilities in the community primarily focus on adults with limited pediatric services, and even fewer options for neonates and infants. It is for this reason that many families opt to have hospice care services in their homes. Neonatal transport programs are key to providing a safe transition to home in support of infants and families with this special need.

Strategic planning and communication between the care teams and family are vital when it comes to palliative transports to home. Here is the who, what, where, when, why, and how in a brief synopsis.

Who

A multidisciplinary approach is a must, and should include the NICU team, transport team, hospice program, case management, social work, pharmacy, respiratory, and any other specialty teams, such as cardiology, nephrology, etc. When it comes to the physical transport, it must be decided what personnel will be needed to accompany the infant, i.e., respiratory or extra nurses. If possible, a secondary team should be assembled to avoid delaying the transport or taking the primary transport team out of service. Also discuss if a parent(s) will be permitted to ride along.

What
Consider what equipment will be utilized and if any special equipment is needed, such as portable oxygen tanks, suction devices, extra syringes or tubing, or a portable monitor. In many cases, minimal monitoring is preferred unless clinically indicated for symptom management. Decide what medications will be given on transport, and if extra doses will be provided as a bridge until the hospice team assumes full care. Opioids such as morphine or fentanyl are commonly used for pain and dyspnea management. Anxiolytics such as midazolam may be considered for agitation or distress, and antisecretory agents such as atropine or glycopyrrolate may be used to manage excessive secretions. Ensure that Medical Orders for Life-Sustaining Treatment (MOLST) or Physician Orders for Life-Sustaining Treatment (POLST) forms are completed and signed. These forms define the scope of interventions, specifying whether interventions such as CPR, intubation, or other life-sustaining treatments should be attempted. They provide clear, actionable medical orders recognized across healthcare settings, including during transport and at home.

Where
Assessing the home site prior to transport is imperative. Key questions include the following:

1. What is the distance that will be traveled?
2. Where will the ambulance be able to park safely and without impeding traffic?
3. Is it a single-family home, townhouse, apartment, or condo?
4. Are there steps outside and/or inside, and how many?
5. Will equipment fit through the doorways?
6. What room will the baby be going to in the home?

When
A date and time should be established that meets the needs of the family and allows coordination between the transport and hospice teams. Ideally, the hospice team will be at the home prior to the arrival of the transport team to ensure a smooth transition of care.

How
A clear timeline and order of operations is helpful and should include specific times for transport team arrival at bedside and hospice team arrival at the home, departure time, transport duration, transition from ambulance to home, cessation of continuous infusions, extubation, and transfer of care.

Other Special Considerations
Some additional considerations may need to be addressed. Assess the need for an interpreter, either in person, online, or via phone. Families sometimes want to incorporate religious or spiritual rituals, so teams should consider including clergy in the planning process. The cost and billing should also be discussed prior to transport to avoid any unnecessary charges to the family that would cause additional stress.

Why
Last, but not least, we cannot forget why palliative transports are important. Simply put, it is because infants and their families deserve to receive compassionate and quality services whether they are life-sustaining or solely to provide comfort at the end of life.

Although much has improved when it comes to palliative and end-of-life care for neonates, resources are still limited and unfortunately this need is sometimes overlooked. Transport teams are in a unique position to improve the existing services for neonates by providing a safe bridge from hospital to home. The standard models of care for neonatal transports serve as a great foundation for the addition of palliative services by building upon the principles of strategic planning, communication, and coordination of resources that are already in place. Transport teams should consider incorporating a guideline to streamline the process for this very important workflow. I personally consider it an honor and a privilege to provide this care for infants and families, and hope that we continue to make improvements in the neonatal community in the future.

Resources

1. Miller RS, Cummings JJ, Macauley R, Ralston SJ. Perinatal palliative care. Obstet Gynecol. 2019;134(3):e84–e95. (ACOG Committee Opinion No. 786).
2. Linebarger JS, Johnson V, Boss RD, et al. Guidance for pediatric end-of-life care. Pediatrics.2022;150(1):e2021053494.
3. Ferrell BR, Twaddle ML, Melnick A, Meier DE. National Consensus Project Clinical Practice Guidelines for Quality Palliative Care, 4th edition. J Palliat Med. 2018;21(12):1684–1689.
4. Association of Women's Health, Obstetric and Neonatal Nurses. Perinatal palliative care. J Obstet Gynecol Neonatal Nurs. 2023;52(2):e1–e18.
5. Stark AR, Pursley DM, Papile LA, et al. Standards for levels of neonatal care: II, III, and IV. Pediatrics.2023;151(1):e2022057776.
6. Lin E, Noritz G. Home health care of children, adolescents, and young adults with complex medical needs: clinical report. Pediatrics. 2025;155(1):e2024061234.
7. Tominaga GT, Mosenthal AC, Livingston DH, et al. Palliative care best practices guidelines. Bull Am Coll Surg.2017;102(11):18–26.
8. Garten L, Bührer C. Pain and distress management in palliative neonatal care. Semin Fetal Neonatal Med.2019;24(3):101041.
9. Hoell JI, Weber HL, Balzer S, et al. Advance care planning and outcome in pediatric palliative home care. Oncotarget.2018;9(80):35051–35060.
10. Breyre AM, Wang DH, Brooten JK, et al. EMS care of adult hospice patients: a position statement and resource document of NAEMSP and AAHPM. Prehosp Emerg Care. 2023;27(2):243–252.
11. Gunaga S, Yang DH, Hanson K, et al. Statewide and regional variation in hospice and palliative care protocols in emergency medical services in the United States. Prehosp Emerg Care. 2025;29(1):1–10.
12. Linton JM, Green A. Providing care for children in immigrant families. Pediatrics. 2019;144(3):e20192077.
13. Ernst KD. Resources recommended for the care of pediatric patients in hospitals. Pediatrics. 2020;145(4):e20200285.
14. Sullivan DR, Iyer AS, Enguidanos S, et al. Palliative care early in the care continuum among patients with serious respiratory illness: an official ATS/AAHPM/HPNA/SWHPN policy statement. Am J Respir Crit Care Med.2022;206(4):e44–e63.

Humidification Strategies During Pediatric Interfacility Transport: Physiologic Principles and Practical Considerations

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Editor's Summary

What is already known on this subject: Humidification is used during invasive and noninvasive ventilation in two forms: active heated humidification and passive humidification using a heat and moisture exchanger. Both methods of humidifying inspired gas have advantages and disadvantages.

What question does this article address: This article describes the methods of humidifying inspired gas, listing advantages, disadvantages, and contraindications for each and how those strategies relate to transport.

What does this article add to the literature: The article describes the use of both humidification strategies in the context of neo/peds transport.

How is this relevant to our clinical practice: Humidification is important during transport of intubated patients. The unique environment of transport introduces operational constraints including space, equipment, and vehicle limitations. This article clearly describes the advantages and pitfalls associated with humidification of inspired gas during transport of neonatal and pediatric patients.

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The upper airway is essential for warming and humidifying inspired gases. This intrinsic function is bypassed during invasive mechanical ventilation, thereby requiring artificial humidification to maintain appropriate gas conditioning. Inadequate humidification under these circumstances may contribute to airway mucosal injury, impaired mucociliary clearance, secretion inspissation, and an increased risk of airway obstruction.[1,2]

Humidification during both invasive and non-invasive mechanical ventilation is achieved through two principal strategies: active and passive systems. Active **heated humidification (HH)** uses an external heated humidifier to condition the inspired gas to near-physiological temperature and humidity before delivery to the patient. In contrast, passive humidification utilizes a **heat and moisture exchanger (HME)**, which conserves heat and water vapor from exhaled gas and returns it to the patient during subsequent inspiration.[1,2] Both heated HH and HME offer distinct advantages and limitations. See Table 1.

HMEs are contraindicated in patients with copious or tenacious secretions, significant air leaks (e.g., around uncuffed endotracheal tubes [ETTs] or in the setting of a bronchopleural fistula), hypothermia (core temperature < 32°C), low tidal volume ventilation, which is frequently encountered in pediatric populations, and in patients with elevated minute ventilation requirements. In such circumstances, HH is generally preferred to ensure adequate gas conditioning and airway protection.[1,3]

Humidity refers to the water vapor content of a gas and is typically expressed as absolute humidity (AH), defined as the mass of water vapor per unit volume of gas (mg/L). In contrast, relative humidity (RH) represents the ratio of the actual water vapor content to the maximum amount the gas can hold at a given temperature, expressed as a percentage. A clear understanding of these parameters is essential when discussing humidification standards and performance requirements during mechanical ventilation.[1,2]

The American Association for Respiratory Care (AARC) clinical practice guidelines recommend that, during invasive mechanical ventilation, active HH delivers inspired gas with an AH of approximately 33 – 44 mg H_2O/L, a gas temperature of 34 – 41°C at the circuit Y-piece, and near-complete saturation (approximately 100% relative humidity). In contrast, HMEs should provide a minimum AH of ≥ 30 mg H_2O/L to be considered acceptable. In neonatal practice, particularly with HFNC, CPAP, and NIMV, HH is commonly regarded as standard care; in older pediatric populations, practice patterns may be more variable, though it is generally recommended to improve comfort and tolerance.[3–5]

Evidence directly comparing HH and HME in neonatal and pediatric populations remains limited. Although a 2017 Cochrane review encompassing 34 randomized controlled trials (n = 2848) found no major differences between HH and HME in predominantly adult populations, only a small number of pediatric studies were included, precluding firm conclusions for infants and children. Available neonatal and pediatric literature suggests that while HME may be feasible in selected short-term settings, important concerns remain regarding inadequate humidity delivery, added dead space, reduced performance in the presence of air leaks, and potential CO_2 retention in smaller patients.[6,7]

Recently, a pilot randomized controlled trial conducted in a tertiary pediatric intensive care unit compared HME and heated humidification in children aged 2–15 years requiring mechanical ventilation for more than 48 hours. The study found no statistically significant difference in ventilator-related adverse events, including ventilator-associated pneumonia and artificial airway occlusion, between the two humidification strategies. Secondary outcomes, including suction frequency, peak inspiratory pressure, ventilator duration, and mortality, were also comparable. Although limited by sample size, these findings suggest that HME may be a feasible and safe humidification option in mechanically ventilated pediatric patients without contraindications.[8]

Pediatric Transport Considerations

In pediatric interfacility transport, humidification remains physiologically indicated in intubated patients. However, transport introduces unique operational constraints, including limited equipment space, power dependency, risk of circuit condensation ("rainout"), vibration, and the need for patient repositioning. These factors may influence device selection independent of ICU practice.[1,2,9]

For short-duration transport, passive humidification with an HME is commonly utilized due to its portability, mechanical simplicity, and absence of water reservoirs or external power requirements. Nonetheless, caution is warranted in neonates and small infants, in whom additional instrumental dead space may contribute to hypercapnia, and in patients with low tidal volume ventilation, significant air leaks (e.g., around uncuffed ETTs), thick secretions, or hypothermia. In high-risk scenarios, active humidification may be preferable when feasible, though its practical implementation during transport can be challenging.[1–3,9]

References

1. Al Ashry HS, Modrykamien AM. Humidification during Mechanical Ventilation in the Adult Patient. *BioMed Research International*. 2014;2014:1-12. doi:10.1155/2014/715434
2. Gross JL, Park GR. Humidification of inspired gases during mechanical ventilation. *Minerva Anestesiol*. 2012;78(4):496-502.
3. Chikata Y, Sumida C, Oto J, Imanaka H, Nishimura M. Humidification Performance of Heat and Moisture Exchangers for Pediatric Use. *Critical Care Research and Practice*. 2012;2012:1-5. doi:10.1155/2012/439267
4. Goodfellow LT, Miller AG, Varekojis SM, LaVita CJ, Glogowski JT, Hess DR. AARC Clinical Practice Guideline: Patient-Ventilator Assessment. *Respiratory Care*. 2024;69(8):1042-1054. doi:10.4187/respcare.12007
5. Restrepo RD, Walsh BK. Humidification During Invasive and Noninvasive Mechanical Ventilation: 2012. *Respiratory Care*. 2012;57(5):782-788. doi:10.4187/respcare.01766
6. Esquinas Rodriguez AM, Scala R, Soroksky A, et al. Clinical review: Humidifiers during non-invasive ventilation - key topics and practical implications. *Critical Care*. 2011;16(1):203. doi:10.1186/cc10534
7. Gillies D, Todd DA, Foster JP, Batuwitage BT. Heat and moisture exchangers versus heated humidifiers for mechanically ventilated adults and children. Cochrane Emergency and Critical Care Group, ed. *Cochrane Database of Systematic Reviews*. 2017;2018(12). doi:10.1002/14651858.CD004711.pub3
8. Parameswaran N, Palanisamy S, Sreevilasan SK, Venkatesh L, Jose D, Bc G. Effect of Heat and Moisture Exchanger vs Heated Humidifier on Ventilator-related Adverse Events in Children: A Pilot Randomized Controlled Trial. *Indian Journal of Critical Care Medicine*. 2025;29(9):746-752. doi:10.5005/jp-journals-10071-25045
9. Section on Transport Medicine AAP, Romito J, Alexander SN. *Guidelines for Air & Ground Transport of Neonatal and Pediatric Patients Manual*. 4th ed. (Insoft RM, Schwartz HP, eds.). American Academy of Pediatrics; 2015. doi:10.1542/9781581109795

Table 1: Comparison of Heated Humidifier Versus Heat and Moisture Exchanger for Invasive and Non-Invasive Mechanical Ventilation: Pediatric Clinical and Transport Considerations

Domain	Heated Humidifier (HH)	Heat and Moisture Exchanger (HME)	Pediatric & Transport Considerations
Airway warming	Actively warms inspired gases	Limited warming capability	Important in hypothermic infants; HME contraindicated if core temp <32°C
Dead space	No added instrumental dead space	Adds mechanical dead space	Clinically significant in neonates and small infants; may increase $PaCO_2$
Airway resistance	Minimal additional resistance	May increase resistance	More relevant in small ETT sizes
Secretion management	Preferred in copious or thick secretions	Contraindicated with tenacious secretions or hemoptysis	Pediatric patients with viral bronchiolitis or pneumonia may not tolerate HME well
Air leaks	Maintains humidification despite leaks	Ineffective with significant air leaks	Concern in air leak syndromes (e.g., uncuffed ETTs, bronchopleural fistulas)
Condensation "rainout"	Risk of circuit condensation	Minimal condensation	Rainout problematic in air transport due to vibration and position changes
Risk of hypo- or hyperthermia	Risk if device malfunction or no flow	Minimal risk	Transport setting increases risk if power interruption occurs
Portability	Bulky; requires power and water reservoir	Compact and lightweight	Advantageous in confined transport environments

Erratum Section of TRANSPORT DISPATCH

This article was originally published without authors listed in error, in Volume 2, Issue 1 of *Transport Dispatch*. The corrected article with authors listed is published here in full.

PEDIATRIC INTERFACILITY TRANSPORTS USING HIGH FREQUENCY PERCUSSIVE FLOW VENTILATION: A CASE SERIES

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Editor's Summary

What is already known on this topic?
HFV is well established in neonatal transport, but data on HFPFV use in older pediatric patients during transport are limited.

What question does this study address?
Is HFPFV a safe and feasible ventilation strategy for transporting pediatric patients with severe PARDS?

What does this study add to the literature?
Seven of eight patients were successfully transported on HFPFV with no transport-related adverse events and 100% survival to PICU arrival. Oxygenation measures improved, and only one patient required ECMO. Operational insights include the need for a standardized setup and team familiarity.

How is this relevant to our clinical practice?
Although this is a small case series, the authors do a good job of supporting the case for HFPFV as a viable transport option for select pediatric patients with severe respiratory failure, particularly in programs already experienced with neonatal HFV.

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Ms. Peterson and Dr. Harris conceptualized and designed the review, collected data, performed data analysis, drafted the initial manuscript, and critically reviewed and revised the manuscript. Dr. Heiman and Dr. Esperanza conceptualized and designed the review, performed data analysis, drafted the initial manuscript, and critically reviewed and revised the manuscript. Mr. Davis collected data, performed data analysis, drafted the initial manuscript, and critically reviewed and revised the manuscript. Ms. Pollard conceptualized and designed the review, and critically reviewed and revised the manuscript. Dr. Scheider conceptualized and designed the review, drafted the initial manuscript, and critically reviewed and revised the manuscript. Mr. Haggerty collected data, and performed data analysis. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Abstract

Objective:
To describe the use of high frequency percussive flow ventilation (HFPFV) during the interfacility transfer of patients with pediatric acute respiratory distress syndrome (PARDS).

Methods:
The study is a retrospective case series from January 2018 to December 2022 on the use of HFPFV and inhaled nitric oxide (iNO) for interfacility transfer of patients with PARDS to a metropolitan children's hospital with a 35-bed Pediatric Intensive Care Unit (PICU) and a center for extracorporeal membrane oxygenation (ECMO) therapy.

Results:
Transport HFPFV was attempted in 8 patients with 7 (87.5%) successful transitions. All patients survived transfer, and there were no adverse events during transport. Only 1 of 7 patients required ECMO support at the receiving facility. There is a trend toward improved oxygenation, as measured by the oxygenation saturation index and the saturation/fraction of inspired oxygen (S/F) ratio.

Conclusions:
HFPFV use in the interfacility transport setting is feasible and safe in pediatric patients.

Glossary of Terms

ABG:	Arterial Blood Gas
ALS:	Advanced Life Support
CCMC:	Cohen Children's Medical Center
CMV:	Conventional Mechanical Ventilation
CPR:	Cardiopulmonary Resuscitation
ECMO:	Extracorporeal Membrane Oxygenation
FiO_2:	Fraction of Inspired Oxygen
HFJV:	High Frequency Jet Ventilation
HFOV:	High Frequency Oscillatory Ventilation
HFPFV:	High Frequency Percussive Flow Ventilation
HFV:	High Frequency Ventilation
iNO:	Inhaled Nitric Oxide
IVH:	Intraventricular Hemorrhage
LOS:	Length of Stay
MAP:	Mean Airway Pressure
NICU:	Neonatal Intensive Care Unit
OI:	Oxygenation Index
OSI:	Oxygen Saturation Index
PARDS:	Pediatric Acute Respiratory Distress Syndrome
PICU:	Pediatric Intensive Care Unit
POCT:	Point of Care Testing
P/F Ratio:	Ratio of Partial Pressure of Oxygen (Arterial) and Fraction of Inspired Oxygen
REDCap:	Research Electronic Database Capture
S/F Ratio:	Ratio of Peripheral Oxygen Saturation and Fraction of Inspired Oxygen
SpO_2:	Pulse Oximetry
TCOM:	Transcutaneous CO_2

Introduction

Regionalization of pediatric services has resulted in the need for interfacility transfers for inpatient care. 9.4% of non-neonatal discharges were admitted via transfer, with respiratory diseases accounting for the most common pediatric condition [1]. While affecting only a small proportion of patients, pediatric acute respiratory distress syndrome (PARDS) is associated with a high mortality rate which can approach 33% in severe cases [2] [3]. The routine use of high frequency ventilation (HFV) for moderate to severe PARDS is discouraged but can be considered for those failing conventional therapy [4]. Such patients are at risk for requiring extracorporeal membrane oxygenation (ECMO), and the interfacility transport of such patients is high risk and challenging with only a select number of transport teams capable of providing therapy.

HFV has been used safely and effectively in the transfer of critically ill neonates with improvements in ventilation and oxygenation [5]. The feasibility and safety profile in pediatric patients has been described in small case series. The largest cohort was reported by Piloquet et al in 2020 [6] with 125 patients, of which 18 (14.4%) were non-neonates. Pediatric patients were transported on high frequency oscillatory ventilation (HFOV) with a survival to discharge rate of 56%.

Cohen Children's Medical Center (CCMC) is an integrated children's hospital with a quaternary-level Pediatric Intensive Care Unit (PICU) and Neonatal Intensive Care Unit (NICU) and is a regional ECMO center. It has had a dedicated pediatric and neonatal transport team since 2005. All interfacility transfers are within the Long Island/New York City, New York, region, a 60-mile catchment area, and are carried out by advanced life support (ALS) ground ambulances. The CCMC transport team was the first in the region to use high frequency percussive flow ventilation (HFPFV) with inhaled nitric oxide (iNO) in the transfer of patients with neonatal respiratory failure. CCMC neonatal HFPFV volume ranges between 15 to 27 transports per year. With the experience gained with neonatal transports and increasing use of HFPFV in our pediatric critical care inpatient setting, we extended its use to the pediatric transport environment and now describe our center's recent experience.

Methodology

This case series is a retrospective review of pediatric patients with severe PARDS transferred to the PICU at CCMC using HFPFV from 2018 to 2022 as potential ECMO candidates. Prior to January 2018, the team transported a few pediatric HFPFV patients with core critical care physician and respiratory therapy expertise. This experience established the feasibility of more frequent use, harnessing insights from these cases. However, team members were trained with a just-in-time model, and there was a long set-up time impacting our out-the-door times.

The cohort described in this review represents all pediatric patients that the team attempted to transport to CCMC using HFPFV during this period. One patient was excluded from analysis as they were unable to transition from conventional mechanical ventilation (CMV) to HFPFV. A patient was considered successfully transitioned to HPFPV if physiologic measurements [heart rate, work of breathing, pulse oximetry (SpO_2), and/or blood gas analysis] and ventilator settings [e.g., mean airway pressure (MAP) and fraction of inspired oxygen (FiO_2)] revealed an improved trajectory. The one patient excluded from analysis could not be oxygenated with either HFPFV or CMV and was safely transported back to the PICU with manual bag-valve-mask ventilation. No other patients were excluded.

This case series was declared exempt by the Northwell Institutional Review Board.

A transport is initiated by a referring physician and is initially triaged through a centralized transfer center and transport nurse. A transfer request that requires PICU is typically attended by the medical control physician, as well, who directs medical care, transport team composition, and transport modality (ground or air). While the call is being triaged, respiratory therapy and transport nurses prepare to launch HFPFV with or without iNO.

Based on patient weight, either the Sinusoidal Bronchotron ® (Percussionaire, Sandpoint, ID, USA, a Division of Sentec, Basel, Switzerland) or the TXP-2D® were used (Percussionaire, Sandpoint, ID, USA, a Division of Sentec, Basel, Switzerland). These are flow-regulated, time-cycled high frequency ventilators. The AeroNox® 1.0 or 2.0 system was used for iNO delivery (International Biomedical, Austin, TX, USA). The apparatus was mounted on a Stryker ® stretcher (Stryker, Portage, MI, USA). The use of HFPFV was determined by the transport team physician in consultation with the medical control physician. The decision to transport using HFPFV was based on whether the patient was on HFV and/or failing CMV at the referring institution.

All patients were monitored with continuous telemetry, pulse oximetry, and either invasive arterial blood pressure monitoring, when available, or intermittent non-invasive blood pressure monitoring. Transcutaneous CO_2 monitoring (TCOM) was not routinely performed. Arterial blood gas (ABG) analysis through point-of-care testing (POCT) was not available during ground transport. The transport team consisted of a critical care physician, transport nurse, respiratory therapist, paramedic, and emergency medical technician. All transports were by ground ambulance.

Data Collection

Data was extracted from the transport program records kept on Research Electronic Data Capture (REDCap) database [7], CCMC electronic medical records, and available records from referring hospitals. Patient demographics, clinical data, outcomes, ventilator mode, ventilator settings, iNO use, and ECMO utilization were collected. The oxygen saturation index (OSI) and SpO_2/FiO_2 (S/F) ratio were calculated using data most proximate to transport team arrival (pre-transport), departure from the referring hospital following transition to transport ventilator (transport), arrival and transition of care to the PICU team (post-transport), and six hours following arrival (6 hours post-transport). Calculations were performed as described by Khemani et al, utilizing the following formulas: $S/F = SpO_2/FiO_2$ and $OSI = (100 \times MAP \times FiO_2)/SpO_2$[2].

The use of OSI as a surrogate for oxygenation index (OI) was based on limited availability of ABG data from the referring institutions and lack of intra-transport ABG data.

Statistical Analysis
Data collection and analysis were conducted with Excel software for Microsoft 365. Continuous data were presented as median and range.

Results
From January 2018 to December 2022, there were 294 patients on invasive mechanical ventilation transferred to the PICU with respiratory failure. Transport HFPFV was attempted on 8 patients (0.03%), and 7 patients (87.5%) were successfully transitioned to transport HFPFV. The average patient transport time was 50 minutes, with an average mileage of 41.7 miles. The team mobilization (call intake to departure) time for these seven patients was 177.7 minutes.

The cohort had a median age of 20 months (2 months to 17 years). 57% were less than 24 months of age, and 71% were female. The median weight was 12.3 kg (3.9-63.2 kg). One of the patients had a tracheostomy, and six were endotracheally intubated. Five (71.4%) patients had an episode of cardiac arrest requiring cardiopulmonary resuscitation (CPR) prior to the transfer request. There were no adverse events (e.g., ventilator failure, unplanned extubation, CPR, or pneumothorax) during transport. All patients survived transport. Average PICU and hospital length of stay (LOS) were 18 and 29 days, respectively. One patient required ECMO, and this patient subsequently expired with an ECMO utilization and mortality rate of 12.5% (Table 1).

TABLE 1. Patient Information

Patient	Age (m)	Gender	Weight (kg)	Diagnosis	Comorbid Diagnosis	Pre-transport CPR	ECMO	Hospital LOS (days)	ICU LOS (days)	Outcome
1	2	F	3.87	Bronchiolitis	Grade 1 IVH*	No	No	28	20	Home
2	20	F	10.4	Tracheal Injury due to Dog Bite	None	No	No	29	23	Home
3	95	F	41	COVID Pneumonia	Asthma	Yes	No	15	10	Home
4	204	M	63.2	Acute Chest Syndrome	Hemoglobin SS	Yes	No	41	41	Home
5	49	M	16.4	Autoimmune Hemolytic Anemia	None	Yes	No	39	13	Home
6	5	F	8	Necrotizing Pneumonia	None	Yes	Yes	11	11	Expired
7	11	F	12.3	Overdose, Aspiration Pneumonia	None	Yes	No	34	12	Skilled Nursing Facility

*IVH = intraventricular hemorrhage

Average mean airway pressure (MAP) pre-transport was 27 (17-32) cm H_2O. Ventilator settings are presented in a supplemental table. Calculation of oxygenation indices during pre-transport, transport, post-transport, and 6 hours post-transport shows a trend of improvement of the OSI and stable S/F ratios (Table 2).

TABLE 2: Ventilator and Oxygenation Parameters

Phase of Care	MAP (cm H_2O)	S/F ratio (median, range)	OSI (median, range)
Pre - transport	27 (17-32)	94 (87-114)	37.95, (20.6-73.8)
Transport	25 (18-35)	90.14 (85-95)	31.05, (20.4-40.6)
Post - transport	23 (18-30)	93.86 (87-99)	25.1, (18.1-31.5)
6 hours post-transport	24 (18-30)	119 (91-188)	19.7 (14-31)

Discussion

There is not a great deal of literature on HFV use in pediatric populations in the transport environment; one example, Piloquet et al [6], describes a cohort of 18 pediatric patients. In comparison with their cohort, our patients show a wide range of age and weight, and have a higher average MAP prior to transport. Our cohort had fewer adverse events, higher survival rates, and lower ECMO utilization. Our retrospective review demonstrates that HFPFV was safely used during ground transport on a small group of pediatric patients ranging in age and size, with no adverse events reported. Our team has extensive experience safely transporting neonates on HFV, and HFV is a common ventilation modality in the CCMC ICUs, suggesting that transport-related risks would be minimal. A pattern of improved oxygenation during transport was observed via OSI, with an overall pattern of improvement with S/F ratios 6 hours post-transport, warranting further study using a larger cohort.

In addition to our team's experience safely transporting neonates on HFPFV, several studies have shown that HFV, with or without iNO use, during neonatal transport can be safe and effective, leading to improved patient ventilation and/or oxygenation [6, 8, 9, 10]. There was a low incidence of adverse events, including not tolerating HFV and pneumothoraces post-transport. Table 3 organizes data from these cohorts (see below). The success of neonatal HFPFV use on transport allowed our team to bridge the skills, select equipment, and experience of our combined neonatal and pediatric teams to the pediatric population by engineering an HFPFV platform for pediatric transport.

Table 3: Previous HFV Transport Cohorts for Neonatal and Pediatric Patients

Paper	Neonatal Patients (n)	Pediatric Patients (n)	Adverse Events (n,%)	ECMO utilization	Survivors (n,%)	Conclusions
Belli, et al, 2022(8)	9	0	0	Not reported	9 (100%)	HFOV appears to be safe for the transportation of newborns with severe respiratory failure
Mainali, et al, 2007(5)	29	0	3 (10%)	4 (13.8%)	27 (93%)	Use of HFJV in transport appears to provide better ventilation and is safe for neonates
Honey, et al, 2007(9)	134	0	6 (4.5%)	1	134 (100%)	Use of HFPFV had a steep learning curve, but was safe for this cohort
Panigrahy et al, 2023(10)	24	0	0	n/a	17 (70.8%)	HFOV ± iNO has proven to be an effective and safe instrument for road transport of newborns with severe respiratory failure.
Piloquet, et al, 2020(6)	107	18	28 (22%)	52 (42%)	74% overall, 78% neonate, 56% pediatric	Higher survival rate at discharge, lower ECMO utilization

Our study has several limitations, including its retrospective nature and small sample size. This limits the ability to draw robust conclusions or perform a meaningful statistical analysis. Our transport program has a compact catchment area with short transport times limiting our ability to study HFPFV effects over long distances and transport times. Future studies that include a wider range of pediatric patients in age and size, wider and different catchment areas (urban, suburban and rural) are needed to determine HFPFV's applicability in these varied settings.

We were also unable to study the effects on ventilation. There was wide variability when ABGs are drawn prior to transition to HFPFV. During the transport phase, TCOM and ABG POCT were not available due to program constraints. We aim to include an assessment of the effects on ventilation in our future studies.

There can be significant time intervals between HFPFV utilization, leading to a lack of skill maintenance and set-up practice. Our team noted that standardizing the HFPFV set-up could decrease departure time. The team mobilization time for these HFPFV transfers was 177.7 minutes. In comparison, the average mobilization time for emergent pediatric jobs requiring a team from 2018 to 2022 was 26.2 minutes. The long set-up time may affect the decision to utilize HFPFV versus CMV in the future.

The analysis of these eight patients along with our ongoing work, resulted in a new HFPFV ground transport platform capable of supporting pediatric patients, comprised of an HFPFV Sinusoidal Bronchotron suitcase, medical gas tanks (three oxygen and two nitric oxide), an iNO delivery system, two intravenous infusion pumps, ground ambulance stretcher, and ancillary supporting equipment. We speculate that the new standardized platform design and regular training will improve deployment efficiency and operational effectiveness.

Our team is developing a pediatric HFPFV training program specific to the needs of each transport discipline (i.e., critical care physician, transport nurse, respiratory therapist, paramedic, and emergency medical technician), to include didactic and practical components, hands-on training, and mock set-up. Phase one of training included a didactic session and hands-on “knobology” class for physicians, respiratory therapists, and transport nurses, which was well attended. A post-survey indicated that attendees felt more competent with the equipment. Phase two is in progress and includes a training video that illustrates the standard ground set-up for physicians, respiratory therapists, transport nurses, paramedics, and emergency technicians. Once this video has been circulated, training drills using the equipment will be scheduled and timed. Future goals include adapting the program for flight and collecting data for a prospective study comparing patient outcomes using CMV versus HFPFV treatment. We also hope to develop an algorithm to determine whether the HFPFV platform should be considered to transport patients not already on HFV based on patient condition and disease.

Conclusions

The regionalization of pediatric care centers places increased demands on pediatric transport teams, necessitating expanded capabilities to safely provide advanced support at the referring institution and transport the sickest patients. Our experience shows that neonatal HFPFV transport capabilities can be successfully adapted for use in older and larger pediatric patients with severe lung disease, allowing for their safe transfer to pediatric lung rescue centers.

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Supplemental Table

TABLE 4. Respiratory Settings Table

Patient	1	2	3	4	5	6	7
Pre-Transport	**HFOV**	**HFOV**	**HFOV**	**HFOV**	**Chart not available**	**HFOV**	**HFOV**
MAP	17	30	27	32		32	26
Freq.	12 Hz	7 Hz	5 Hz	8 Hz		11 Hz	3 Hz
FiO_2	100	100	100	100		80	100
iNO	20	20	20	20		n/a	20
Intra-Transport	**HFPFV**	**HFPFV**	**HFPFV**	**HFPFV**	**HFPFV**	**HFPFV**	**HFPFV**
MAP	18	30	28-36	35	35	20	20
Freq.	360 bpm	420 bpm	440 bpm	Not charted	Not charted	400	600
FiO_2	100	100	100	100	100	100	80
iNO	20	20	20	20	20	n/a	20
Post-Transport	**HFPFV**	**HFOV**	**HFOV**	**CMV**	**HFPFV**	**HFPFV**	**HFPFV**
MAP	18	30	28	27	22	22-25	21
Freq.	360 bpm	7 Hz	5 Hz	12 bpm	550 bpm	450 bpm	600 bpm
FiO_2	100	100	100	100	100	100	100
iNO	20	20	20	20	20	n/a	20
6h Post-Transport	**HFPFV**	**HFOV**	**HFOV**	**CMV**	**CMV**	**HFPFV**	**HFPFV**
MAP	22	30	26	18	20	22	30
Freq.	390 bpm	7 Hz	5 Hz	12 bpm	PSV	600 bpm	600 bpm
FiO_2	100	100	50	100	80	80	80
iNO	20	20	20	20	20	n/a	20

Abbreviations

CMV: Conventional Mechanical Ventilation

FiO_2: Fraction of Inspired Oxygen

Freq.: Frequency (expressed in breaths per minute, unless otherwise noted)

HFOV: High Frequency Oscillatory Ventilation

HFPFV: High Frequency Percussive Flow Ventilation

Hz.: Hertz (1 Hertz = 60 breaths per minute)

iNO: Inhaled Nitric Oxide

MAP: Mean Airway Pressure (measured in cm H_2O)

PEEP: Positive End Expiratory Pressure (measured in cm H_2O)

PSV: Pressure Support Ventilation

RR: Respiratory Rate (expressed in breaths per minute)

1. Rosenthal JL, Hall M, Hain PD, et al. Profiling interfacility transfers for hospitalized pediatric patients. *Hosp Pediatr*. 2016;6(6):345-353.
2. Khemani RG, Smith LS, Zimmerman JJ, et al. Paediatric acute respiratory distress syndrome incidence and epidemiology (PARDIE): an international observational study. *Lancet Respir Med*. 2019;7(2):115-128.
3. Shein SL, Slain KN, Rotta AT, et al. Epidemiology and outcomes of critically ill children at risk for pediatric acute respiratory distress syndrome: a Pediatric Acute Respiratory Distress Syndrome Incidence and Epidemiology study. *Crit Care Med*. 2022;50(3):363-374.
4. Emeriaud G, Khemani R, Jouvet P, et al. Executive summary of the second international guidelines for the diagnosis and management of pediatric acute respiratory distress syndrome (PALICC-2). *Pediatr Crit Care Med*. 2023;24(2):143-168.

5. Mainali ES, Nagappala KB, Lakshminrusimha S, et al. Safety and efficacy of high-frequency jet ventilation in neonatal transport. *J Perinatol*. 2007;27(10):609-613.
6. Piloquet JE, Hamon I, Roze JC, et al. A twelve-year neonatal and pediatric high-frequency oscillatory ventilation transport experience. *Pediatr Pulmonol*. 2021;56(5):1230-1236.
7. Harris PA, Taylor R, Minor BL, et al. The REDCap consortium: Building an international community of software platform partners. *J Biomed Inform*. 2019;95:103208.
8. Belli G, Paternoster G, Tartarisco T, et al. Safety use of high frequency oscillatory ventilation in transport of newborn infants affected by severe respiratory failure: preliminary data in central Tuscany. *BMC Pediatr*. 2022;22(1):335.
9. Honey G, Watkins M, Stacey F, et al. Use of the Duotron transporter high frequency ventilator during neonatal transport. *Neonatal Netw*. 2007;26(3):167-174.
10. Panigrahy N, Sridhar A, Chowdhury P, et al. High frequency oscillatory ventilation (HFOV) and inhaled nitric oxide (iNO) use during neonatal emergency transport—feasibility and efficacy in India. *Indian J Pediatr*. 2024;91(12):1268-1270.

Welcome to the Educational and Reflective Section of

TRANSPORT DISPATCH

Neonatal Pioneer: Physician Julius Hess

Beth C. Diehl, DNP, NNP-BC, CCRN

Dr. Julius Hess was a pediatrician who fundamentally transformed the care of premature and critically ill infants. Hess's work laid the foundation for neonatal medicine as it exists today and is widely recognized as the "Father of American Neonatology."

Dr. Hess was born on January 26, 1876, in Ottawa, Illinois. After earning his medical degree from Northwestern University School of Medicine in 1899, he interned at Alexian Brothers' Hospital from 1899-1900 in Chicago. It was there that he became keenly interested in the care required by premature infants so that they could not only survive but thrive. He subsequently sought additional pediatric and neonatal training at Johns Hopkins Hospital in Baltimore, Maryland in 1900. Infant mortality rates were troubling throughout his early medical career and specialized neonatal care was limited.

He visited Europe several times between 1900 and 1910 to garner additional information about rudimentary infant incubators and other neonatal care practices. Dr. Hess used this knowledge to develop one of the first infant incubators in 1914, a definitive game changer for ongoing thermal management. The incubator consisted of a combined water jacket with insulation and electric heating from a large plate. He further refined his design and developed an incubator suitable for neonatal transport by 1922. He then designed an incubator capable of administering oxygen by 1934.

In 1919, he published "Principles and Practice of Infant Feeding". Subsequently, in 1922, Dr. Hess established the first premature infant station at the Sarah Morris Hospital in Chicago and directed the station for the next 30 years and with nurse colleague Evelyn Lundeen was able to achieve a 73% survival rate. He brought to the forefront the principles of thermoregulation, infection control, minimal handling, and breast milk feeding utilizing special techniques. In 1922, his textbook entitled, "Premature and Congenitally Diseased Infants," became a foundational document for generations of pediatricians and nurses.

In Chicago, in 1934, in concert with the Board of Health, Dr. Hess established a neonatal transport program that was supported by a 24-hour ambulance service with specialized equipment and nurses trained in premature infant care. At an American Academy of Pediatrics meeting in 1935, Dr. Hess endorsed the recommendation than premature infants be classified as those weighing 2500 grams or less regardless of gestation. This guideline was subsequently adopted by the World Health Organization in 1950 as a driver for premature care policies and recommendations.

As the father of two daughters himself, Hess advocated a comprehensive approach and emphasized the importance of nutrition, infection prevention, and family involvement in the plan of care. He partnered with nurse Evelyn Lundeen, another neonatal pioneer, and co-authored "The Premature Infant: It's Medical and Nursing Care" in 1941 in the twilight years of his career. His methods for premature care were modeled across the United States and throughout the United Kingdom.

Dr. Hess passed away suddenly on November 2, 1955, at the age of seventy-nine. His legacy is one of high-level scientific contributions conjoined with compassion for neonates and their families. Today, neonatal intensive care units (NICUs) reflect the principles Hess established, ensuring that the smallest and most vulnerable neonates receive the best possible start in life.

In Neonatal and Pediatric Transport

Tammy Rush MSN RN, C-NPT, EMT, Editor, *Transport Dispatch*

In neonatal and pediatric transport, progress is never accidental—it's the result of teams who are willing to learn from their own practice and from one another. As we continue to highlight excellence across our community, I want to encourage every program to look closely at their data over time. Trends, patterns, and outcomes tell a story that single transports cannot, and those stories help guide meaningful improvement. Sharing these insights across teams strengthens our collective understanding and elevates the standard of care we provide. Pairing data review with regular protocol updates, thoughtful evaluation of training methods, and timely feedback to clinicians ensures that our practice remains current, consistent, and responsive to the needs of the infants and children we serve.

Our work is demanding, but it is also deeply collaborative. When we commit to reflection and continuous refinement, we honor the trust placed in us by patients, families, and referring teams. Thank you for the dedication you bring to every transport—and for the ongoing commitment to learning that keeps our field moving forward.

The Transporter's Brain

Fran Byrd MPH RN NNP-BC

Every now and then, a little mental meandering is good for stimulating thought processes and awareness.
SO... let's assume you have a critical care transporter's brain focused on the needs of the neonatal and/or pediatric populations you serve. If so, how specifically might your brain be wired to handle the role and its demands? Have you ever wondered why you were drawn to a profession that so often includes situations likely to fall outside your comfort zone in terms of the knowledge or skills required across a complex range of needs?

Could it be those professionals drawn to this somewhat unique calling, have brains that are specifically tuned to the needs of those populations for whom they provide essential support and care? And might it even mean that transport team members who work so well together share a core of some, but not all, brain attributes related to transport? In fact, could it be that the ability to work so well as a team might be an indication that beyond the common core of attributes, the diversity of thought processing among individual transport team members actually complements the overall performance involved in patient assessment and care?

This "flight of fancy" regarding the potential for such a profession-specific focused brain was originally triggered by an article in the 2020 *Air Medical Journal* (The Neonatal Transporter's Brain, Bellini C, *Air Medical Journal*, 2020-01-01, Volume 39, Issue 1, Pages 24-26). Don't let the title lead you to believe the content is neonatal specific. The discussion involves universal characteristics with application across the entire scope of a critical care transport professional's role.

In his lecture, Bellini presented a blank drawing of the regions of the brain and then added suggested specific characteristics and the percentage of time involved in relation to the demands of critical care transport and the corresponding role of the specialty-focused transport professional. His final rendering (in English here for clarity) of "The Transporter's Brain" identified: Bravery (15%), Instinct (40%), Cautiousness (8%), Imagination (15%), Rationality (10%), Independence (12%).

Truly, a thought-provoking topic. Personally, while reflecting on the characteristics that evolved in Bellini's presentation, I felt strongly that there was an attribute missing in the discussion. This attribute reflects both the art and science of transport and is a foundational part of the care teams provide by air or ground. Please save some brain space in recognition of …Compassion.

Now! Just imagine a transport team meeting where the challenge is thrown out to identify the characteristics and percentages of brain space needed to create the "perfect brain balance of attributes" required for transports based on the perceptions of your own transport team members! Might be an eye-opening event. On a larger scale, it might even lead to some surveys of multiple transport teams with roles involving different patient ages, geographic distributions, or transports requiring highly specialized equipment or technology. Who knows, based on the resulting input, it might even stir up article-authoring juices and an updated look at the evolution of the critical care transporter's brain and role in "saving children one transport at a time".

AAP Section on Transport Medicine Roster