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Feature Article

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A B S T R A C T

Registered nurses are core members of critical care ground transport teams because of their education, experience, and scope of practice. Advances in medicine, technology, and equipment, combined with regionalization of specialized care and, most recently, the coronavirus disease 2019 pandemic, necessitate that transport nurses possess specialized knowledge, skills, and abilities. National specialty certification in ground transport nursing via the Certified Transport Registered Nurse (CTRN) offers registered nurses a process to validate their expertise. The most recent transport nursing role delineation study, which was conducted by the Board of Certification for Emergency Nursingin 2019, provided the foundation for the revised CTRN examination content outline, which is now separate from the Certified Flight Registered Nurse (CFRN) content outline. In this article, we provide a brief history of the specialty of ground transport nursing; details on the CTRN examination blueprint; and a composite patient case report to illustrate the ground-specific role, expertise, and contributions of the CTRN in delivering the highest level of patient care during ground transport.

Nurses have been involved in the ground transport of patients since the advent of the nursing profession. Florence Nightingale and Clara Barton were actively involved in transporting patients from the battlefields.[1] In the 1960s, when paramedicine was just getting started in the United States, nurses were used for interfacility ground transports.[2] This predated the first civilian helicopter transport programs of the 1970s.[1,2] Although many transport registered nurses (RNs) currently flex between flight and ground modes, there is also a group of dedicated critical care transport RNs who primarily function in the ground transport environment.[3]

With their autonomous, wide scope of practice and in-hospital experience, RNs are important members of critical care ground transport teams. These teams typically also include a paramedic and an emergency medical technician driver and may also include a respiratory therapist, a perfusionist, and/or a specialty physician. In recognition of RNs who work in the unique environment of critical care ground transport, the National Flight Nurses Association changed its name to the Air & Surface Transport Nurses Association (ASTNA) in 1998.[4]

Specialty Settings Warrant Specialty Expertise

To provide safe, appropriate, evidence-based care in the transport setting, RNs must obtain knowledge and experience beyond their initial education and training.[5] Specialty certification independently validates an RN's advanced knowledge, skills, and experience across a well-defined specialty practice area.[6] ASTNA's position statement on transport nurse certification supports specialty certification in critical

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care transport nursing and recognizes that specialty certification is positively associated with patient safety and positive patient outcomes.[7] The Commission on Accreditation of Medical Transport Systems (CAMTS) also places a high value on the education and training of health care professionals responsible for providing care in the out-of-hospital transport environment.[8] CAMTS has required specialty certification of RNs since 2010.[9] Furthermore, according to the current draft of the upcoming 12th edition accreditation standards[10] and CAMTS Executive Director Eileen Frazer (personal communications, November 2021), CAMTS will require "transport specific certification" that is "pertinent to the scope of care and patient population" and will continue to accept non–transport-specific advanced certification until that current certification expires.

The Certified Transport Registered Nurse Is Born

The Board of Certification for Emergency Nursing (BCEN) and ASTNA have long recognized the unique role of ground transport RNs. In 2004, these organizations jointly funded a role delineation study (RDS) and determined the role of the critical care ground transport RN was sufficiently different from the role of the air transport RN. Therefore, the separate Certified Transport Registered Nurse (CTRN) specialty certification was born. BCEN went on to develop the CTRN credentialing program and offered the first CTRN examination in March 2006. That same year, CAMTS recognized the CTRN in its 7th edition accreditation standards.[11] Beginning with the 8th edition, when specialty certification for critical care transport RNs was first required, the CTRN was 1 of several credentials that met the CAMTS standards.[9] Also, in 2009, the CTRN was designated as an American Nurses Credential Center Magnet–accepted certification.[12]

Nurses with advanced knowledge and special training in critical care transport are ideal members of a ground transport team. CTRNs bring the critical thinking skills and knowledge acquired from working in the intensive care unit (ICU) and/or emergency department (ED) with the understanding of the unique challenges that come with moving patients of all ages safely outside of the hospital environment. This includes an understanding of a multitude of critical care therapies, the stressors of transport, the need for excellent communication skills, and the ability to work as part of an interdisciplinary team in an autonomous and uncontrolled out-of-hospital environment.

Present-Day Critical Care Ground Transport

With the regionalization of cardiac, stroke, and trauma centers and specialty neonatal and pediatric centers, patients with complex conditions and interventions often need to be transported to receive the definitive care they need (Fig. 1). Air medical transport is 1 option, but factors such as weather, space, and weight limitations may preclude the safe transport of some patients by air. Ground transport offers the flexibility to add additional equipment and personnel and may not have the same limitations as air travel (Fig. 2).

With the coronavirus disease 2019 (COVID-19) pandemic, limited bed availability has led to increased numbers of patients being transported over greater distances. The transmissibility of COVID-19 and the unknowns early in the pandemic further elevated the level and complexities of patient care and crew safety (Fig. 3). Until personal protective equipment protocols were established and before the vaccine was available, many programs did not fly patients who were on noninvasive ventilation because of the concern for disease transmission due to aerosolizing droplets. Many of these patients also required extracorporeal membrane oxygenation, and, as a result, many flight programs did not transport because of the weight and size of the equipment. Bariatric patients have been hit particularly

Figure 1. The complex therapies (eg, multiple intravenous infusions, Impella heart pump (ABIOMED, Danvers, Massachusetts), and ventilator) of this ICU patient with severe cardiogenic shock and HR were maintained during transport by the CTRN, CCP-C, and perfusionist on board for the 127-mile transport to a cardiac specialty center for possible heart transplant or long-term left ventricular assist device placement. (Courtesy of Parkview Health.)

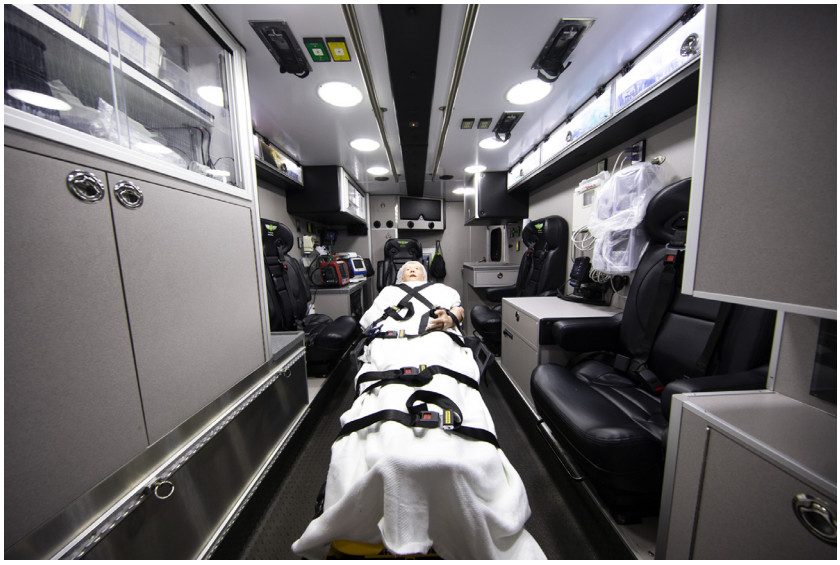

Figure 2. Critical care transport vehicles like Parkview Health's MICU Ford F-550 with an Osage Ambulance Super Warrior "68" box have the capacity to hold up to 4 caregivers in the patient care area, along with multiple pieces of equipment, medications, and supplies to maintain the high level of care provided in the ICU. This MICU has a liquid oxygen system that holds 5 to 6 times more oxygen than a standard ground ambulance. (Courtesy of Ryne Hastings, Parkview Health.)

hard by COVID-19, many of whom have to be transported by ground due to weight and space allowances of air transport. Having a CTRN as part of the critical care ground transport team helps ensure these patients receive the highest level of care.[13]

All of these factors are likely contributing to a recent surge in the number of CTRNs.

After multiple years of mostly modest growth, the number of CTRNs increased by 19% in 2020 and 26% in 2021 (based on data through November 22, 2021) (Fig. 4).

The Path to CTRN Examination Specifications: The RDS

A role delineation study (RDS) is a scientific inquiry to identify the tasks and work activities conducted, the context in which those tasks and activities are performed, and the competencies (knowledge, skills, and abilities) required to perform a job role successfully.[3] An RDS is an essential method for determining the content of certification assessments and is usually the first step in the development of a certification examination (Fig. 5). Specifically, the RDS outlines essential information about the development and use of an examination including 1) content, 2) the scope of the certification, 3) the numbers of items on the examination, and 4) the types of items on the examination.[14] Crucial to the ongoing success of a certification examination is the concept of validity. Validity refers to how accurately an assessment measures what it is intended to measure. An RDS serves as a key piece of content validity that is necessary for a certifying body to ensure the accuracy and legal defensibility of an examination.[3]

Approximately every 5 years, BCEN conducts an RDS to ensure that examination content is current, accurate, and relevant. The most recent ground transport RDS was conducted in 2019 with the

Figure 3. Ground transport nurses and paramedics are trained and have special dispensation to perform advanced interventions to stabilize critical patients during transport. This staged photograph provides an example of the types of personal protective equipment used in transport. (Courtesy of Ryne Hastings, Parkview Health.)

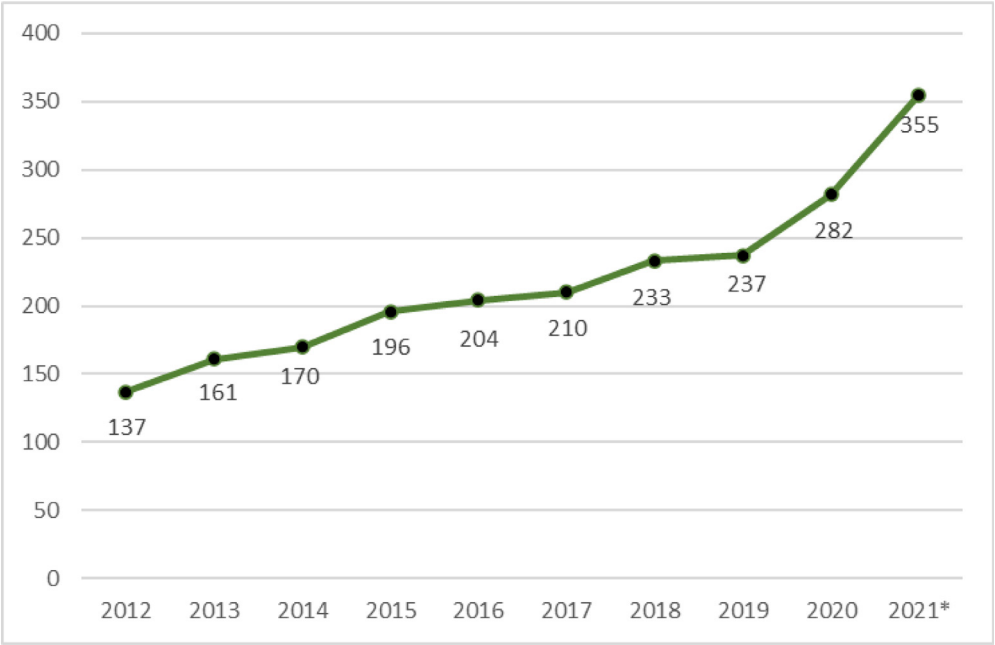

Figure 4. The number of CTRN credential holders as of November 22, 2021, according to the BCEN CTRN database.

assistance of BCEN's test development partner, PSI Services LLC (Glendale, CA). A group of 12 subject matter experts, known as the RDS Advisory Committee (AC) and representing a wide variety of geographic and practice settings and years of experience in the specialty, were selected by BCEN to assist PSI Services LLC with discussing the scope of practice and developing a list of tasks and knowledge areas that reflect the role of the ground transport RN.

The RDS process can include a variety of data collection methods; BCEN uses a mixed-methods approach using qualitative data (subject matter expert panel meetings) and quantitative data (survey of CTRN-certified and non-CTRN transport nurses). PSI Services LLC developed, administered, and monitored a survey to validate the tasks and knowledge areas identified by the RDS AC. The survey was sent to over 4,000 certified and noncertified transport RNs, and there was an 11% response rate. The results of the survey were reviewed by the RDS AC and provided BCEN with a representation of the CTRN candidate population in terms of geographic, demographic, and practice diversity data (Table 1).

A First for the CTRN: A Separate Content Outline

Since the first RDS that included both ground and flight nursing was conducted in 2005, a combined Certified Flight Registered Nurse

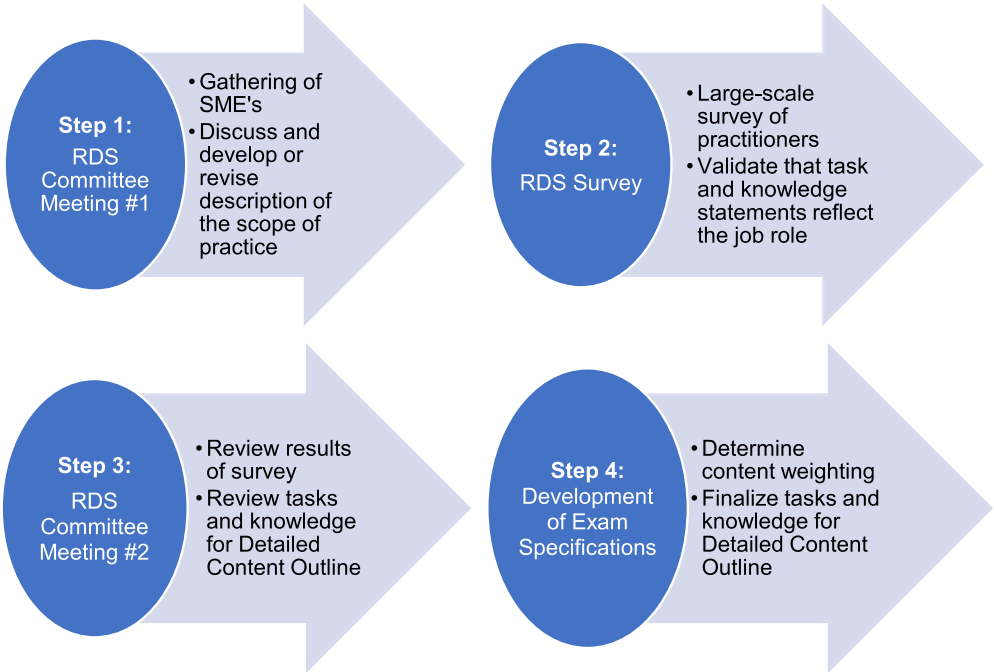

Figure 5. The steps of the RDS process.

Table 1
Transport Registered Nurse (RN) and Program Demographics From the 2019 Transport Nursing Role Delineation Study

Region of primary practice, n (%)	Northeast	33 (26)
	Midwest	28 (22)
	South	36 (28)
	West	30 (24)
Percentage of transports in each category, mean (SD)	Ground	65.6 (36.2)
	Rotor wing	26.3 (32.2)
	Fixed wing	8.1 (20.3)
Years of nursing experience, mean (SD)	Years as RN	18.2 (11.0)
	Years as transport nurse	11.4 (9.0)
Highest nursing degree obtained, n (%)	Diploma	8 (6)
	Associate degree	20 (15)
	Bachelor's degree	67 (51)
	Master's degree	34 (26)
	Doctoral degree	2 (2)
Certifications held,[a] n (%)	Certified flight registered nurse	93 (71)
	Certified transport registered nurse	26 (20)
	Certified emergency nurse	73 (56)
	Certified pediatric emergency nurse	23 (18)
	Trauma certified registered nurse	17 (13)
	Critical care registered nurse (CCRN) adult	35 (27)
	CCRN pediatric	4 (3)
	CCRN neonatal	2 (2)
	CCRN-K	0 (0)
	Certified in neonatal pediatric transport	12 (9)
	Certified flight paramedic	12 (9)
	Certified critical care paramedic	4 (3)
	Certified medical transport executive	9 (7)
Specialty nursing experience before transport nursing, n (%)	ED	53 (40)
	ICU	22 (17)
	Both ED and ICU	50 (38)
	Other	6 (5)
Type of ED experience,[a] n (%)	Adult	98 (75)
	Pediatric	69 (53)
	Trauma center	79 (60)
Type of ICU experience,[a] n (%)	Surgical	42 (32)
	Medical	43 (33)
	Cardiovascular	40 (31)
	Neurologic	29 (22)
	Trauma	34 (26)
	Pediatric	17 (13)
	Neonatal	9 (7)
	Burn	8 (6)
Primary role, n (%)	Critical care ground transport nurse	55 (42)
	Flight/ground transport nurse	76 (58)
	Flight nurse	0 (0)
Primary position, n (%)	Ground transport nurse	59 (45)
	Flight nurse	48 (36)
	Advanced practice registered nurse	2 (2)
	Chief flight nurse/supervisor	8 (6)
	Educator	9 (7)
	Program director	5 (4)
Percentage of patients in each population,[a] mean (SD)	Adult	65.5 (29.4)
	Pediatric	23.6 (24.3)
	Neonatal	6.3 (10)
	Perinatal (ie, high-risk obstetrics)	4.7 (5.8)
Percentage of patient transports by type, mean (SD)	Interfacility	80 (25)
	Scene	20 (25)
Which best describes your primary program affiliation, n (%)	Hospital based	74 (56)
	Community based	31 (24)
	University hospital	18 (14)
	Public service	7 (5)
	Military	1 (1)
Country of practice, n (%)	United States	126 (96)
	Canada	2 (2)
	Other	3 (2)
Transport program performs transports across international borders, n (%)	Yes	29 (22)
	No	102 (78)

ED = emergency department; ICU = intensive care unit.
[a] Respondents were asked to select all that apply.

(CFRN) and CTRN detailed content outline[15] has existed, noting those areas that would be excluded from the CTRN examination (eg, flight physiology). The results of the 2019 transport nursing RDS survey were used to finalize the tasks and knowledge that comprise the revised CTRN examination content outline,[16] which was published in September 2021 and went into effect for examination takers as of February 28, 2022. Although the 2019 RDS AC recognized substantial content that ground transport and flight nurses both need to know to practice in their specialty competently and effectively, content specific to ground transport nursing was also identified. In light of these findings, it is clear that ground transport RNs should be recognized for those unique sets of knowledge, skills, and abilities.[3] As a result of the 2019 transport nursing RDS, there are now separate outlines for the CFRN[17] and CTRN examination. The CTRN examination consists of 130 test questions that span 5 content areas (Fig. 6).

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Certified Transport Registered Nurse (CTRN) Examination Content Outline

	Total items
1. General Principles of Ground Transport Nursing Practice	**19**
A. Transport physiology	**3**
1. Physiologic stressors of transport (e.g., vibration, altitude changes, noise)	
a. Crew	
b. Patients	
B. Scene Operations Management	**2**
1. Scene safety (e.g., hazmat, exposures)	
2. Response mode	
3. Emergency vehicle operations	
C. Communications	**3**
1. Radio operations (e.g., equipment, medical control, paging operations)	
2. Patient handoff (e.g., history from referring provider, updates for receiving provider, SBAR)	
3. Crew resource management	
D. Safety and Survival	**2**
1. Navigation (e.g., maps, GPS)	
2. Survival principles (post-crash)	
3. Transport vehicle emergencies	
4. Pre-mission preparation (e.g., shift preparedness, risk assessment, crew briefings, weather)	
E. Disaster Management (e.g., natural, terrorism, industrial accident, transportation accident, mass casualties, Incident Command System)	**1**
F. Professional Issues	**5**
1. Legal Issues	
a. HIPAA	
b. EMTALA	
c. Consent	
d. Mandatory reporting (e.g., abuse, neglect, medication diversion, non-accidental trauma)	
e. Legal concepts in patient care (e.g., advanced directives, negligence, assault, battery, abandonment)	
2. Ethical Issues	
3. Psychosocial issues in transport, including families	

Figure 6. Revised CTRN content outline (effective February 28, 2022) (https://bcen.org/wp-content/uploads/2021/08/CTRN-Content-Outline-effective-2.28.22.pdf).

What Is New: Outline Changes and Separate Item Bank

The revised CTRN content outline[16] reflects numerous changes, several of which are highlighted here. The entire general principles of nursing practice domain (section 1) is now specific to ground transport. Second, shock is now its own subcategory under resuscitation principles (section 2), both in the new CTRN outline and the revised CFRN outline, because shock is more accurately a function of perfusion and resuscitation. Previously, in the combined CFRN/CTRN content outline,[15] shock was a subcategory in both the trauma and medical emergencies domains.

Also of note is the new mental health considerations subcategory in the medical emergencies domain (section 4). The 2019 RDS demonstrated that patients presenting with mental health issues are becoming more common in the ground transport environment; therefore, CTRNs should have specific knowledge in this area. Contributing factors include an increase in the number of patients with

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Certified Transport Registered Nurse (CTRN) Examination Content Outline

	Total items
G. Systems Management	**3**
1. Quality management	
2. Just Culture	
3. Healthy work environment (e.g., wellness program, stress management)	
4. Outreach and community education	
2. Resuscitation Principles	**33**
A. Principles of Assessment and Patient Preparation	**4**
1. Physical assessment	
2. Pain and comfort assessment	
3. Preparing the patient for transport (i.e., packaging)	
B. Airway	**6**
1. Airway assessment	
2. Airway management	
3. Difficulties encountered with airway	
4. Rapid Sequence Induction for Intubation (RSI), including pharmacology	
5. Post-intubation management, including pharmacology	
C. Mechanical Ventilation	**10**
1. Invasive ventilation	
2. Non-invasive ventilation	
D. Perfusion	**13**
1. Components of oxygen delivery	
a. fluid resuscitation	
b. blood products	
c. vasopressors	
2. Shock and resuscitation management, including trauma and medical	
a. Hypovolemic	
b. Obstructive	
c. Distributive	
d. Cardiogenic	
3. Acid base imbalances	

Figure 6 Continued.

mental health/substance abuse–related issues presenting for emergent care[18] and crew and patient safety concerns regarding transporting such patients in the confines of the flight environment. In special populations (section 5), a new subcategory structure includes trauma, medical, and pharmacologic considerations for each population.

Going forward there will be a separate examination item bank for the CTRN examination, and item development will focus exclusively on questions applicable specifically for ground transport practice. When recruiting for CTRN item writers in 2022 and beyond, BCEN will prioritize RNs with ground-specific expertise who hold the CTRN credential.

Ground Transport Case Report Highlighting CTRN Care

The following patient case report and the discussion that follows highlight the role and select contributions of the CTRN-certified RN. Patient demographics were changed for patient confidentiality.

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	Total items
3. Trauma	**22**
A. Principles of Management	**5**
1. Mechanism of injury	
2. Hemostasis (e.g., TXA, tourniquets, hemostatic agents)	
3. Trauma triad (i.e., hypothermia, acidosis, coagulopathies)	
4. Immobilization	
B. Neurologic	**4**
1. Traumatic brain injuries	
2. Spinal cord injuries	
3. Secondary brain injury	
C. Thoracic	**4**
1. Chest wall injuries	
2. Pulmonary injuries	
3. Cardiac injuries	
4. Great vessel injuries	
D. Abdominal	**2**
1. Hollow organ injuries	
2. Solid organ injuries	
3. Diaphragmatic injuries	
4. Retroperitoneal injuries	
5. Abdominal compartment syndrome	
E. Musculoskeletal	**3**
1. Vertebral injuries	
2. Pelvic injuries	
3. Compartment syndrome	
4. Rhabdomyolysis	
5. Amputations	
6. Extremity injuries	
F. Burn	**2**
1. Chemical burns	
2. Electrical burns	
3. Thermal burns	
4. Radiological burns	
5. Inhalation injuries	

Figure 6 Continued.

Pediatric Intracranial Hemorrhage

The transport distance was 140 miles, the transport time was 2 hours, and the total patient time was 2 hours 45 minutes.

History of Present Illness

A 15-year-old male presented to the ED via ambulance after a mental status change. Family members stated he was "lethargic" and fell, striking his head on the bed frame. Once in the ED, his level of consciousness continued to deteriorate, with new onset of generalized tonic-clonic seizure activity. The patient was electively intubated for airway protection and was placed on the ventilator in the ED. Computed tomographic and magnetic resonance imaging scans of his head revealed multiple parenchymal hemorrhages with a 3-mm midline shift. Laboratory test results revealed thrombocytopenia with a platelet count of 28,000/μL (normal range, 150,000-450,000/μL), severe leukocytosis, white blood cell count of 1,179,700/μL (*normal range*, 3,400 - 10,500/μL), lactic acid of 4.1 mmol/L (normal range, 0.4-2.0 mmol/L),

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Certified Transport Registered Nurse (CTRN) Examination Content Outline

	Total items
G. Maxillofacial and Neck	**2**
1. Facial injuries, including fractures	
2. Ocular injuries	
3. Blunt and penetrating neck injuries	
4. Medical Emergencies	**39**
A. Neurologic	**5**
1. Seizure disorders	
2. Ischemic stroke (e.g., blood pressure management)	
3. Neuromuscular disorders	
4. Space occupying lesions (e.g., bleeding, tumors, abscesses, hydrocephalus)	
B. Cardiovascular	**10**
1. Acute coronary syndrome	
2. Heart failure	
a. pulmonary edema	
b. structural defects	
c. infectious or inflammatory processes	
3. Dysrhythmias	
4. Aortic abnormalities (e.g., hypertension, blood pressure management)	
5. Mechanical/circulatory support (e.g., ECMO, IABP, VAD, pacing)	
C. Pulmonary	**6**
1. Restrictive airway disease (i.e., COPD, Asthma)	
2. Obstructive airway disease (e.g., acute lung injury/ARDS, pulmonary infections)	
3. Pulmonary embolism	
4. Pulmonary hypertension	
D. Abdominal	**2**
1. Abdominal compartment syndrome	
2. GI bleed	
3. Conditions of the hollow organs (e.g., obstruction, rupture)	
4. Conditions of the solid organs (e.g., pancreatitis, hepatitis)	
E. Electrolyte Disturbances	**2**

Figure 6 Continued.

elevated prothrombin time of 16.7 seconds (normal range, 9.2-11.2 seconds), and an international normalized ratio of 1.7 (normal range, 0.9-1.1). While in the ED, the patient was given prothrombin complex concentrate, levetiracetam, lorazepam, and antibiotics and was transfused with a unit of platelets. Because of the weather conditions, the rotor wing aircraft was not available to rapidly transport the patient to a pediatric specialty resource center. The mobile intensive care unit (MICU) was requested to transport this patient by ground.

Assessment

Upon crew arrival, the patient's vital signs, history, and laboratory values were reviewed. The pertinent vital signs included the following: blood pressure of 134/84, heart rate (HR) of 93, respiratory rate of 21 to 25 breaths/min, and end-tidal carbon dioxide ($ETCO_2$) of 25 to 28 mm Hg. Repeat laboratory values were pending. The transport crew entered the room and found the patient actively seizing with tonic-clonic seizures with decerebrate posturing. His pupils were 8 mm and sluggish to react to light. Additional lorazepam was given

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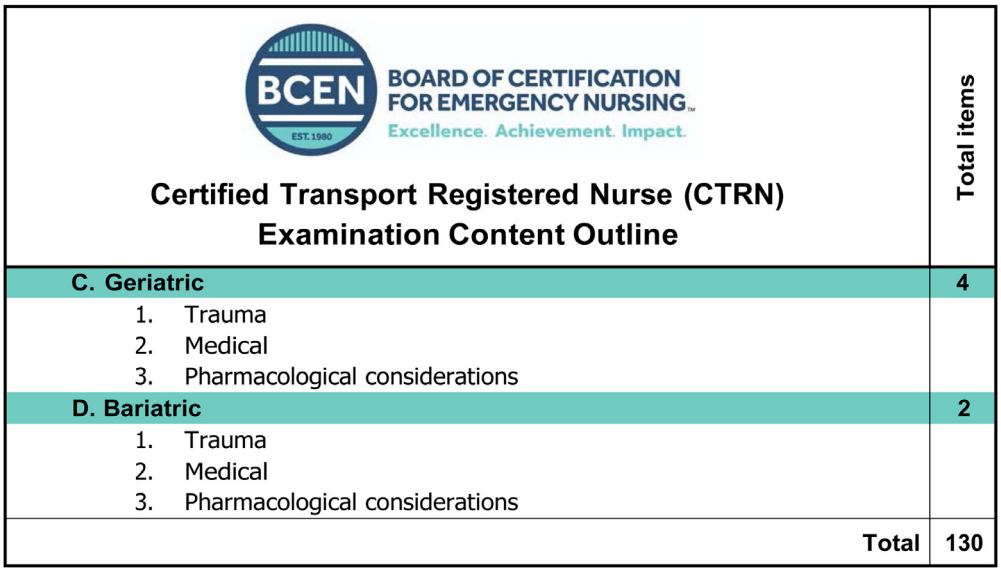
Certified Transport Registered Nurse (CTRN) Examination Content Outline

	Total items
F. Metabolic and Endocrine	**3**
1. Diabetic emergencies	
2. Neuroendocrine disorders (e.g., diabetes insipidus, SIADH, HHNK)	
3. Thyroid conditions	
4. Adrenal disorders	
G. Hematology	**1**
1. Coagulopathies (including platelet disorders)	
2. Anemias	
H. Renal	**2**
1. Acute kidney injury	
2. Chronic renal failure	
I. Infectious and Communicable Diseases	**4**
1. Sepsis	
2. Infection control (e.g., MRSA, influenza-like illness, highly-infectious diseases)	
J. Environmental and Toxicological Emergencies	**3**
1. Environment	
a. Allergic reactions	
b. Cold related (e.g., hypothermia, frostbite)	
c. Heat related (e.g., heatstroke, heat exhaustion)	
d. Submersion injuries (i.e., drowning, near drowning)	
e. Bites and envenomation	
2. Toxicology	
K. Mental Health Considerations	**1**
5. Special Populations	**17**
A. Obstetrical Patients	**5**
1. Trauma	
2. Medical (e.g., complications of pregnancy)	
3. Pharmacological considerations	
4. Delivery and post-partum care	
B. Neonatal/Pediatric	**6**
1. Trauma	
2. Medical	
3. Pharmacological considerations	

Figure 6 Continued.



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Certified Transport Registered Nurse (CTRN) Examination Content Outline

	Total items
C. Geriatric	**4**
1. Trauma	
2. Medical	
3. Pharmacological considerations	
D. Bariatric	**2**
1. Trauma	
2. Medical	
3. Pharmacological considerations	
Total	**130**

Figure 6 Continued.

as an intravenous push (IVP), and his seizures ceased. Propofol was infusing, and the patient was being mechanically ventilated. Decerebrate posturing was noted with nail bed pressure. Bruising was present on his right cheek bone. The patient's skin was pale, cool, and dry. Several petechiae were present on his upper chest, bilateral axilla, and abdomen. Multiple bruises were also present on his lower extremities. His urine output was low, approximately 15 mL/h since admission, and was thick, cloudy, and dark yellow in color. He was placed on the transport ventilator by the certified critical care paramedic (CCP-C). The patient's weight was 59 kg, with an ideal body weight of 55 kg based on his height. The ventilator settings were based on his ideal body weight to ensure the lung protective ventilation strategy was met. The ventilator mode was synchronized intermittent mandatory ventilation, pressure-regulated volume control, rate of 16 breaths/min, tidal volume of 350 mL, positive end-expiratory pressure of 5 cm H_2O, pressure support of 10 cm H_2O, and fraction of inspired oxygen of 0.4. Peak inspiratory pressures were 16 to 17 cm H_2O throughout transport. He tolerated the transport ventilator well with synchrony and adequate rise and fall of his chest wall. Because of patient complexity, preparation for transport took the crew approximately 45 minutes.

Transport

The transport crew continuously assessed the patient for any neurologic changes, seizure activity, and signs of bleeding. To assist with oxygenation and ventilation, the propofol drip was titrated for optimal sedation, and Sublimaze (McNeil Laboratories, Fort Washington, PA) was given to improve and maintain comfort. His initial core temperature was 97.8°F per temperature-sensing indwelling urinary catheter. To help prevent worsening hypothermia, platelets and intravenous fluid boluses were given via a fluid warmer, and cabin heat in the MICU was optimized. Twenty-five minutes into transport, tonic-clonic seizure activity was again observed. The patient was remedicated with 2 mg lorazepam IVP, and his seizures briefly ceased. A midazolam drip was initiated at 2 mg/h, and his seizure intensity decreased and became more focal and tremorlike. The midazolam drip was titrated to 4 mg/h; his seizures stopped and remained absent for the duration of the transport. Despite fluid resuscitation, additional platelets, adequate sedation, and pain management, his HR continued to rise, and his $ETCO_2$ decreased to the mid-20s despite successful ventilator management by the CCP-C. His skin became paler and cool, and it was apparent his perfusion was worsening. His electronic health record revealed his hemoglobin had dropped from 16 g/dL on admission to 7 g/dL on repeat laboratory tests drawn before departure from the sending facility. The CTRN initiated a unit of packed red blood cells via the onboard fluid warmer. The patient was closely assessed for blood transfusion reaction. His HR, $ETCO_2$, and urine output improved shortly after the blood transfusion was initiated. His urine output increased from 15 mL/h to approximately 200 mL/h during transport. After a 2-hour ground transport, the patient's core temperature had increased to 98.6°F, and his seizures remained controlled with the midazolam drip on arrival to the receiving hospital.

Outcome

The patient was diagnosed with a rare form of lymphoma. Due to a lack of platelets and a history of falls, the patient had multiple parenchymal hemorrhages involving the supratentorial parenchyma and left pons. After several weeks at a specialty hospital with frequent multidisciplinary team meetings and interventions, the patient was discharged home and began outpatient rehabilitation.

Case Discussion Highlighting CTRN Contributions

This patient presented to the ED with trauma-related injuries due to a history of falls. The new onset of seizures correlated with diagnoses of multiple parenchymal hemorrhages that resulted in a 3-mm midline shift of the brain. The care and management of this patient during transport involved the MICU crew continuing the same high level of care the patient was receiving in the hospital for the 2-hour transport. The crew included a CTRN, a CCP-C, and an emergency medical technician.

Because of multiple intraparenchymal hemorrhages, the patient's head was elevated and kept midline to decrease intracranial pressure. Because of a critically low platelet count, the patient was also at a higher risk for additional intercranial bleeding. Positioning, sedation, and adequate perfusion were crucial to his management. The CTRN and crew understood the additional stressors of ground transport (eg, temperature, vibration, and ambient noise) and adjusted the medications to compensate for increased movement and external stimulation, which can often lessen the effect of sedation and

Figure 7. The CTRN uses various tools to maintain patient comfort and stability and lessen the effects of the stressors of transport, such as a fluid warmer (shown here) used to maintain body temperature or regain normothermia while the patient receives intravenous fluids or blood products during transport. (Courtesy of Ryne Hastings, Parkview Health.)

Figure 8. Critical care ground transport is challenging, but the CTRN is confident and well prepared to provide the best care to every patient they encounter every time regardless of the challenges the road brings. (Courtesy of Ryne Hastings, Parkview Health.)

analgesia. The propofol drip was titrated up for optimal sedation, and fentanyl was given by intermittent IVP to improve comfort. Pillows were used to pad pressure points to reduce the transmission of vibration to the patient and to help decrease the effect of the stresses of transport on him during transport.

The CTRN recognized the need for normothermia to improve overall perfusion and decrease vasoconstriction in the setting of multiple new intracranial hemorrhages. With external winter temperatures of 30°F, the cold can seep from the outside environment up into the floor of the ambulance box, decreasing the ambient temperature. Additional interventions had to be taken to ensure the patient's temperature was maintained during transport. He was wrapped in a thermal cocoon and blankets to maintain his body temperature. Intravenous crystalloid fluids, platelets, and packed red blood cells were given via the fluid warmer during transport (Fig. 7). The patient's core temperature improved in transport.

Twenty minutes into transport when seizures resurfaced, the patient was successfully medicated with lorazepam, but knowing the likelihood of seizures reoccurring with multiple parenchymal hemorrhages, the CTRN initiated a midazolam drip and titrated it up until seizures stopped. With the continuous midazolam drip, the seizures were controlled for the remainder of the transport. Throughout the transport, the CTRN monitored for any signs of increasing intracranial pressure, which included monitoring the patient's response to pain, assessing for abnormal posturing, and monitoring his pupil size and reactivity. Although this can be difficult to assess while a patient is receiving sedation, it is critical to closely monitor for any changes that occur.

The patient was also monitored for any new signs of bleeding. This included closely monitoring vital signs, including $ETCO_2$. Although $ETCO_2$ is primarily used to monitor ventilatory status, it can also help determine when overall perfusion is worsening. During the transport, despite adequate ventilator support, signs of worsening perfusion were present, which included a drop in the $ETCO_2$, increased paleness, continued low urine output, and increased HR. Although the patient's blood pressure was being maintained, the CTRN knew that at any point the patient could rapidly decompensate. The decision was made to transfuse a unit of packed red blood cells via the fluid warmer. On arrival to the receiving facility, the overall condition of the patient had improved. Seizures were controlled, and there were no changes in his neurologic condition. His vital signs were stable, and his core temperature was within normal limits.

The CTRN and crew used experience and knowledge to assess the patient and determine how to manage him while factoring in the additional stressors of transport (eg, vibration, noise, environmental temperature, road conditions, and confined space) and limited energy reserve due to severe illness. The CTRN was prepared by having medications and specialty equipment ready for any deterioration in the patient's condition. The CTRN and CCP-C maintained an ICU level of care through medication and blood administration, ventilator management, and the use of specialty equipment during transport.

Conclusion

The complex, autonomous, and evolving critical care ground transport environment demands expansive clinical knowledge and skills, critical thinking, and flexibility. With their education, scope of practice, and experience, RNs bring unique qualifications and contributions to critical care ground transport teams (Fig. 8). The CTRN credential validates ground-specific expertise to colleagues, employers, patients, and families.

The new CTRN examination content outline, which went into effect at the end of February 2022, offers the most specific description of the critical care ground transport nursing body of knowledge and provides the most detailed blueprint for RNs preparing to sit for the CTRN examination to date. As the number of CTRNs increases, the publication of more CTRN-involved case studies and clinical outcomes research will further elucidate the contributions of certified transport nursing practice and help advance the specialty.

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