A pediatric transport system should be capable of rapidly delivering advanced pediatric skilled critical care to the patient's bedside at the referring hospital and of maintaining that level of care during transport to the receiving hospital. Physicians and others with special expertise in pediatric transport have developed specific recommendations for pediatric transport systems. The Committee on Hospital Care of the American Academy of Pediatrics, in collaboration with expert consultants, offers the following guidelines for pediatric transport. These recommendations require periodic review as new equipment, techniques, and data evolve in this rapidly progressing field. Some of these recommendations may need modification to fit local circumstances. This statement modifies and enlarges upon a previously published chapter in the AAP manual, Hospital Care of Children and Youth. Neonatal transport systems have many of the same characteristics.

**OPTIMAL COMPONENTS OF A PEDIATRIC AIR-GROUND SYSTEM**

The most important components of a pediatric transport system are medical control by a qualified pediatric specialist and a medical transport team composed of individuals qualified to care for critically ill children in a transport setting. Although a pediatric transport system may share components with an adult transport system (e.g., dispatch, vehicles, emergency medical technicians), it should have its own medical director, its own protocol, a transport team specifically trained in pediatric critical care, and equipment and supplies appropriate for the care of pediatric patients.

An optimal pediatric transport system has available to it both air and ground ambulances combined into a flexible, coordinated system. Three factors argue for such a system:

1. A pediatric transport system should be capable of responding to any call with a transportation mode that will permit optimal medical care. For some critically ill pediatric patients, speed of transport will be the highest priority. However, for the majority of pediatric patients requiring transfer, other considerations will be of greater importance.

2. Changing weather and traffic conditions frequently impact on the appropriate mode of transport.

3. A pediatric transport system must transport a critical number of patients to maintain the skills of the team members. A combined air-ground system may, in many situations, enable a system to reach a critical transport volume not attainable by either system operating independently.

In addition to the mode of transportation, other important aspects of an effective pediatric transport system include:

1. Well-defined protocols dealing with specific clinical situations.

2. Effective communication between receiving and referring hospitals and the transport vehicles. This may be coordinated by a communications center staffed continuously by trained dispatchers. This facilitates communications between receiving hospital, referring hospital, transport team, and ancillary support services such as security personnel.

3. Vehicles that provide adequate space, climate control, safety, and power sources.

4. Self-contained, mobile intensive care equipment.

5. Detailed protocols dealing with (a) selection of vehicles or aircraft appropriate for a given pediatric transport and (b) specific nonclinical situations such as vehicle failure and requests by a family member or members to ride in the transport vehicle.

6. Data collection to evaluate and support feedback and outreach programs.

7. Feedback and outreach programs to promote
the coordination of care between the receiving hospital, referring hospital, and the transport system.

8. A cost center to provide a method of establishing fees and billing and with the capability of interacting with state agencies and third-party payors.

PERSONNEL

The key to a successful transport system is the selection and training of personnel involved. Team personnel should be chosen for their medical skills and their ability to deal sensitively with personnel at the referring and receiving hospital, with parents, and with each other.

The personnel chosen for a given medical transport and their duties will vary depending on the patient's diagnosis and clinical condition and with the availability of different types of medical personnel in a given system.

The composition of the transport team may vary from situation to situation and will be determined by the pediatrician responsible for a given transport. Specific criteria should be established for determining the team composition for a given transport. The selection of the team is made from a pool of personnel trained in pediatric transport. This pool includes physicians (at least at the PL-III level), nurses, respiratory therapists, and emergency medical technicians. For patients with complex problems, pediatric intensivists should be available to serve as team members.

Transport team members should be dually trained and competent, not only in pediatric critical care but also in transport medicine, managing the supplies and equipment required by the transport vehicle, the physiologic effects of transport on the patient, and the limitations imposed by the transport equipment.

Factors that affect the selection of medical transport team members include:

1. Formal training and competence in pediatric surface and air transport—All members should complete a planned formal training program approved by the medical director and supplemented by in-service practical training. The course should be of sufficient duration and content to cover all responsibilities related to the care and monitoring of pediatric patients during transport, technical skills required for emergency management, operation of transport equipment, adaptation to the physical environment of transport vehicle, and physiologic consequences of the transport on the patient.

2. Physical limitation—Physical and emotional limitations must be considered because these may be hazardous to the member and his or her ability to function as a team member. Factors to be considered include general physical condition, response to stress, ability to withstand fatigue, susceptibility to motion sickness, physical agility, enthusiasm, and commitment.

3. Participating registered nurses and respiratory therapists should have at least one year of critical care experience in pediatrics. Emergency medical technicians and paramedics should have specific pediatric training and experience.

Referrals are made and accepted based upon the judgment of the referring physicians rather than upon a specific set of criteria. Physician judgment has proved to be a more effective basis for transport than specific medical indications. It often is difficult to ascertain the true condition of the patient over the telephone. In general, a patient should be transferred when, in the physician's judgment, the referring hospital lacks the personnel and/or facilities to provide optimal ongoing care. The indication for referral should be because of the medical condition according to prearranged transfer agreements rather than because of economic conditions, time of day, or day of week.

CRITERIA FOR CHOOSING THE MODE OF TRANSPORTATION

The choice of the mode of transportation is determined by:

1. The optimal interhospital transport time indicated by the nature and severity of the patient's clinical condition.

2. Carrier and personnel availability.

3. The region's geography.

4. Weather and traffic conditions.

5. Cost.

The first factor is of paramount importance. If a patient's medical condition is unstable, even a minimal shortening of transport time to the referring hospital by one mode of transportation rather than another may be lifesaving.

In general, for patients requiring a lifesaving procedure that can only be performed at the receiving hospital (e.g., evacuation of an intracranial hematoma), a difference in round trip transport time (air or ground) must be quickly estimated and used as a prime determinant of the mode of transport chosen.

In general, it is recommended that a large urban-suburban area should have helicopters and surface ambulances available, and those serving rural areas should have surface, helicopter, and fixed-wing airplane ambulances available.

Data on comparable safety of the various modes of medical transportation are not available. Surface ambulances should travel at speeds within the legal limits; the ambulance siren and lights should be
used only if necessary to aid in passage through busy intersections without traffic delays. Air transport carriers must observe weather and landing/take-off restrictions. Undue haste generally is unsafe and may be counterproductive.

When choosing an ambulance operator (surface or air), one must carefully evaluate records of safety, availability, financial stability, and compliance with both federal and state regulations.

There are advantages and disadvantages to each mode of transport:

1. Surface ambulance—Advantages include (a) universal availability, (b) only two transfers of the patient en route (hospital to ambulance and ambulance to hospital), (c) the ability to more readily divert (abort) the transport to an intermediately placed hospital in an emergency, (d) an adequate environment for mobile intensive care, and (e) relatively low maintenance costs. Disadvantages include (a) increased transit times when distances are long, (b) mobility is limited by road, traffic, and weather conditions, and (c) not all standard ambulances have adequate power, suction, and ventilatory gas capability.

2. Helicopter—Advantages include (a) rapid transport time, and (b) the ability to reach otherwise inaccessible areas. Disadvantages are (a) an adequate, unobstructed landing space (heliport) is required, (b) if a designated landing area is not adjacent to the hospital, transfer of the patient and equipment to a ground ambulance is required, (c) limited fuel capacity restricts the range to 150 miles, (d) cabin space is limited, (e) noise and vibration may interfere with monitoring, (f) cabin pressurization capability is absent, and (g) maintenance costs are very high.

3. Fixed-wing aircraft—Advantages include (a) a rapid transport time over long distances, (b) the ability to fly above or around inclement weather, (c) cabin pressure capability may be available, and (d) the cabin size is adequate for patient monitoring and management; thus, a full transport team can usually be accommodated. Disadvantages are (a) at least four patient and equipment transfers (hospital to ground and ground to air ambulances and vice versa) are required, (b) runways of sufficient length are needed, (c) the airport may be some distance from either the referring or receiving hospital, requiring the service of an adequately equipped surface or helicopter ambulance, and (d) maintenance costs are high.

**PEDIATRIC MEDICAL TRANSPORT EQUIPMENT**

Selection of equipment is determined by the specific types of transports expected. The transport team should bring all equipment and drugs necessary for stabilization and transport; referring hospitals may have limited resources and capabilities. Equipment should meet the following guidelines for both air and ground transport:

1. Provide capability for pediatric life support in the transport setting.
2. Be self-contained, lightweight, and portable.
3. Be easily cleaned and maintained.
4. Be packaged to allow continuous critical care while entering and exiting from ambulances and aircraft.
5. Have portable, self-contained power for twice the expected transport duration.
6. Have AC power capability.
7. Not interfere electromagnetically with navigation and communications systems.
8. Be durable to withstand severe mechanical, thermal, and electrical stress and repeated use.

For infants, it may be necessary to provide a battery-powered incubator designed to fit through standard hospital doors, capable of being loaded into a standard ambulance by two persons, and securely attachable to an ambulance rail-mounting system. The incubator should have proper attachments for all components considered a part of the transport system and the capability of direct connection to ambulance oxygen and power supplies. If the unit requires a 2,585-mm Hg (50-psi) oxygen source, then it must be able to connect directly to the ambulance oxygen by a standard connection. If a 2,585-mm Hg (50-psi) oxygen source is not required, then the transport unit must have a standard oxygen flow meter, capable of delivering up to 15 L/min. The flow meter must have a standard single adaptor to which the unit’s ventilatory system can be connected. Both the air and ground components used should be able to supply adequate oxygen for twice the expected duration of the transport. The unit should maintain physical integrity when subjected to a 4-g impact deceleration in the vertical and horizontal directions.

Certain equipment must be battery powered and independent of the surface and air carrier’s electrical power. If the carriers have electrical power readily and easily available for use, two hours of independent battery capability should be provided. If ambulance carrier electrical power is not readily available, independent battery power for the transport equipment will be required for twice the anticipated transport time.

All medical supplies and equipment should be evaluated prior to transport and be compatible with each other and with the equipment of the surface and air ambulances used. All medical supplies and equipment should meet applicable federal and state
requirements and Federal Aviation Administration hazardous materials regulations. All equipment should be capable of functioning throughout the entire range of temperatures and barometric pressures anticipated during the transport.

For air transport, all medical supplies and equipment should be labeled as to effective functional time duration and their capabilities at specific altitudes. Each oxygen cylinder should be labeled as to its gas volume and the number of minutes oxygen will be available at a given flow rate.

COMMUNICATIONS

Communication between the transport coordinator, transport team leader, and the referring physician is essential. The physician responsible for the transport should be able to communicate with the transport team at all times.

All air transports must be linked directly air-to-ground by a communications system. The physician responsible for the transport should be able to communicate with the transport team at all times. An interactive emergency medical communications system is also a required component. This communications system brings into contact as needed the referring team, the dispatcher, the transport coordinator, the medical transport team, and the surface and/or air ambulance carriers. This system is required for medical and legal reasons and to ensure that interaction between the various components is as smooth as possible.

The organization and mechanics of the communications system will vary with the resources available. The following components should be incorporated:

1. Receipt of request—All requests for transport should be channeled promptly to the transport coordinator.

2. Internal communication—A critical element is locating and informing transport personnel when a request has been received. Required personnel may not always be on the scene. The speed with which they can be located and assembled is of vital importance.

3. External communication—Where such resources are available, the transport system should be linked to a central dispatch system within the community. These resources include police, fire, and emergency medical service backup.

4. Follow-up—Follow-up on the patient's diagnosis, therapy, and clinical condition should be provided to all referring physicians and hospitals at appropriate intervals. This facilitates the transfer of patients back to the referring hospital, enhances the willingness of physicians to make referrals, and provides an excellent opportunity for informal discussion and education.

Family members who are unable to accompany or to follow the patient should be contacted and given a report on the child’s clinical condition as soon as possible after the transfer to relieve their anxiety. However, additional follow-up contacts are most appropriately handled by the receiving physicians rather than the transport system.

RECORD KEEPING/CLINICAL EVALUATION

Record keeping is essential to monitor the system and to plan for its future. A physician-initiated transport system should provide data to determine which children should be transported and the resources required to safely transport children with various conditions. These data should also indicate which children should not be transported either because their clinical condition is too unstable or because they are not expected to survive.

Clinical evaluation may be used to assess the capabilities and resources of referring hospitals in which children with certain diagnoses are treated prior to transport. Such evaluation provides the basis for feedback to referring facilities or for the development of continuing education programs. The data should be gathered, recorded, and distributed in strictest confidence between the transport system and each referring institution or physician.

Any transport system that transports more than approximately 300 pediatric patients per year should investigate the advantages of computerizing the data gathered in the interest of accuracy, efficiency, and effectiveness. Responsibility for data collection should be assigned to specifically designated personnel. The data should be monitored to ensure consistency and accuracy. Feedback should be provided to the transport team so that they are aware of how the data are used.

The data to be collected include the following:

1. Demographic data to assess changes in the geographic area served.

2. Clinical data to assess and monitor changes in the types of conditions transported and the length and type of hospitalization.

3. Operational data to assess the utilization of different types of equipment and personnel and to evaluate such factors as the time lines of the transport (ie, did it arrive at the referring hospital on schedule) and the appropriateness of the personnel included in the transport team (eg, how often was respiratory therapist used or needed).

4. Initial diagnosis and status evaluation, clinical course, and discharge diagnosis for team education and outreach education.
REGIONALIZATION

To achieve maximum cost effectiveness and optimal patient care, the transport system should be regional in scope and used by multiple facilities. The transport system should be based at a facility with pediatric tertiary care capabilities to ensure optimal patient care. However, physicians should be encouraged to transfer patients to a variety of receiving facilities, not just to the transport system’s base hospital, depending upon availability of specialized services, availability of beds, and physician preference. The system should include as receiving hospitals all hospitals with secondary or tertiary care capabilities that are willing to accept the full medical and financial responsibilities associated with a receiving facility.

In addition to multiple receiving facilities, the system should allow for and encourage the transport of patients back to each referring hospital when their clinical condition permits. Such a system should encourage the most efficient use of pediatric and emergency care facilities throughout the region and promote cooperative efforts among institutions, leading to an overall upgrading of pediatric care.

LIABILITY

Liability for the medical care of the patient during transport and the safety of the medical transport team will vary depending on the legal circumstances of the region and/or state in which the pediatric transport system functions. Nevertheless, the basis for the liability should be firmly established and clearly understood by all of the participants and users of the transport system.

APPENDIX I. Components of Ground and Air Transport Team

<table>
<thead>
<tr>
<th>Personnel</th>
<th>Qualifications</th>
<th>Responsibilities</th>
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<tbody>
<tr>
<td>Medical director</td>
<td>Physician, specialist in pediatric emergency medicine or critical care, trained in transport medicine</td>
<td>Assumes overall program responsibilities, designs team training program, recertifies team members, interfaces with hospital administration, develops policies and protocols for transport system, assures development of outreach and follow-up programs</td>
</tr>
<tr>
<td>Transport coordinator</td>
<td>Physician, specialist in pediatric emergency medicine or critical care, trained in transport medicine</td>
<td>Assures individual transport responsibility including acting as attending physician for the patient during transport, emergency consultant for referring physicians, determines composition of individual transport team and appropriate mode of transport, coordinates management plans with team physician for specific transports</td>
</tr>
<tr>
<td>Physician</td>
<td>Certified by medical director</td>
<td>Coordinates team efforts including patient stabilization, management and monitoring en route</td>
</tr>
<tr>
<td>Transport team</td>
<td>Medically competent, trained in transport medicine</td>
<td>Participates as a team leader on a physician-led team, participates as a team leader as appropriate under protocol</td>
</tr>
<tr>
<td>Transport nurse</td>
<td>Registered nurse licensed to practice within state, minimum of 6 mo of pediatric critical care or emergency medicine experience, trained in transport medicine, if acting as team leader, has 12 mo of pediatric critical care experience and 6 mo experience as a team member</td>
<td>Assists in pulmonary stabilization and airway management</td>
</tr>
<tr>
<td>Respiratory therapist</td>
<td>Registered or registry eligible, experienced in pediatric critical care or emergency medicine, trained in transport medicine</td>
<td>Assists team leader with stabilization and management of patient during transport</td>
</tr>
<tr>
<td>Emergency medical technician (EMT)</td>
<td>Certified or licensed within state, trained in transport medicine, trained in pediatric cardiopulmonary resuscitation, supplemental training/experience in pediatrics</td>
<td>Assists team leader with stabilization and management of patient during transport</td>
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APPENDIX II

Guidelines Specific for Air Transportation of Pediatric Patients

To minimize the effects of altitude on patients, most commercial aircraft are pressurized with atmospheric air by use of a compressor. However, aircraft are not pressurized to sea level but to a differential of approximately 8.6 psi. As altitude increases, atmospheric pressure decreases from 760 mm Hg (14.7 psi) at sea level to 176 mm Hg (3.40 psi) at the usual commercial aircraft operational level (10,600 m [35,000 ft]).

In flight at 10,600 m (35,000 ft) where the atmospheric pressure is only 176 mm Hg (3.40 psi) the cabin compressor adds another 445 mm Hg (8.60 psi) so that the total pressure is 620 mm Hg (12.0 psi), or the approximate atmospheric pressure at an altitude of 1,515 m (5,000 ft). (Differential pressure = actual flight/cabin altitude.) The alveolar \( P_{O_2} \) will decrease proportionately to approximately 80 mm Hg (1.55 psi).

The partial pressure of oxygen in the cabin, therefore, is always decreased above flight levels of 6,818 m (22,500 ft). This reduction in oxygen pressure is a major consideration in the transport of patients with vulnerability to hypoxia due to impaired cardiopulmonary function. A low \( P_{O_2} \), together with possible acidosis, may cause pulmonary hypertension, hypoxemia, and associated ventilatory and cardiac decompensation as the plane ascends.

For safe transport, air ambulances should be pressurized if the flight involves altitudes greater than 1,818 m (6,000 ft) above sea level. Because the artificially pressurized cabin atmosphere reduces but does not necessarily eliminate the effects of altitude, many patients require supplemental oxygen. Relative hypoxia may have adverse effects not only on the patient but also on the transport team members, impairing their clinical judgment during the flight.

Any air flight, even in a pressurized cabin, results in a decrease in ambient pressure, causing an expansion of gases in the body cavity. Expanding gas trapped in a lesion such as a pneumothorax, a lung cyst, or an intestinal diverticulum may cause serious pressure on a vital organ, critical interference with lung expansion, or rupture of a diseased viscus. Trapped gas in the middle ear cavity or the sinuses expands in volume; if the cavity is not sufficiently ventilated, pressure causes discomfort or severe pain.

Changes in barometric pressure also alter the rate of flow of intravenous solutions. In transit, a battery-operated infusion pump is the only reliable method of controlling the rate of flow.

Gravitational factors, such as accelerative and decelerative forces, if not pronounced, have not been a major problem during flights. Vibrations, usually low frequency but high amplitude, and a high noise level are present, especially in helicopters. The noise level masks heart and lung sounds, interfering with cardiac and blood pressure observations by stethoscope. On extended flights, the noise may increase fatigue of the transport team. Humidity is very low aboard aircraft and affects the transport of patients with pulmonary problems. Ambient temperature decreases as the plane ascends and air ambulances must be artificially heated.

Finally, turbulence may cause motion sickness in both patients and transport team members. All equipment must be securely restrained, and glass containers and weighted traction devices must be avoided. The attendants must be prepared to suction vomitus to avoid aspiration.

Because of the disadvantages listed above, medical care during transport differs vastly and presents to professionals disadvantages in comparison to the hospital intensive care area.

Air Ambulance Operator Requirements:
1. Is certified and licensed by the Federal Aviation Administration (FAA) and other federal, state, and local agencies in air ambulance operations.
2. Is capable of carrying out a designated and an alternate flight plan which includes the availability of appropriate intensive care at the destination.
3. Maintains an operating manual for each participating medical group.
4. Is adequately insured, with coverage on file, for aggravation of injury and for combined needs of the medical transport team, the patient, and accompanying family members.
5. Uses appropriate aircraft for pediatric air transport.
6. Provides 24-hour, seven-day per week service.
7. Provides access to operations on an emergency basis.
8. Has a response time of less than 45 minutes at all times. Organization and arrangements should preclude preventable delays. Potential delays should be anticipated and not be recurrent.
9. Employs medical advisors skilled in aeromedical pediatric procedures and available at all times. Aeromedical consultant(s) must approve all preflight plans regarding suitability for transport of any pediatric patient.
10. Provides all transport personnel with appropriate training sessions including periodic updates. Training should be updated at least annually by participation in a course on pediatric transport. For proficiency in patient transfer, the medical team personnel should participate directly in exercises of service operations every 6 months. This includes on and off loading of equipment and simulated patients. This requirement may be waived if several successful pediatric transports have occurred during this time period.
11. Provides ambulance personnel adequately trained in pediatric care in aeromedical factors of transport.

Fixed-Wing Air Ambulance Aircraft Requirements:
1. Be capable of carrying out the flight plan and an alternative plan that includes provision for potential delay.
2. Be multiengine, investigational flight rules (IFR) type, with a cruising range of four hours plus IFR reserves at 75% power.
3. Have on board all equipment of federal aviation regulation (FAR), part 135, day or night, capable of all-weather operation.
4. Be capable of restricting interhospital flight time to less than two hours, except under unusual circumstances.
5. Have a cabin pressure differential to atmosphere air pressure of at least 207 mm Hg (4.0 psi).
6. Have adequate door size and configuration for ingress/egress of the patient, the medical personnel, and medical equipment without compromising the patient's environment or life-supporting systems and without having to tilt the patient when loading into the aircraft.
7. Have cabin space and configuration compatible with the patient's medical transport supplies and equipment; should be adequate to provide for continuous medical management en route by the entire medical team.
8. Maintain a neutral thermal environment for the patient and a comfortable environment with adequate ventilation for the medical team.
9. Provide a method of delivering air and oxygen to the patient care area. Outlets should be compatible with the equipment of the transport team (or vice versa). The system should supply air and oxygen at 2,585 mm Hg (50 psi) for a time period equal to the fuel time.
10. Provide a supply of oxygen, separate from that of the patient, to the medical transport team for a period equal to the fuel time.
11. Include an electrical system, compatible with the transport equipment, that provides sufficient power for a time period equal to the fuel time plus two hours; should include a 115-V, 60-Hz AC power source with a three-prong double receptacle capable of operating with either engine inoperative; minimum capacity of 500 W recommended, and comparative DC voltage as needed for the transport equipment.
12. Provide a suction unit capable of creating a continuous vacuum up to 200 cm H2O.
13. Provide secure frame-anchoring device for all equipment including incubators and air-oxygen bottles.

Rotary Wing Air Ambulance (Helicopter) Requirements:
1. Be capable of carrying out the flight plan and an alternative plan including provisions for potential delays.
2. Restrict interhospital flight time to less than two hours except under unusual circumstances.
3. Have adequate door size and configuration for ingress/egress of patient during loading/unloading.
4. Have cabin space and configuration compatible with the pediatric transport supplies and an adequate working area to allow for continuous medical management by the transport team en route.
5. Maintain a neutral thermal environment for the patient and a comfortable environment for the team.
6. Minimize cabin noise level in conformation with current Office of Safety and Health Administration (OSHA) standards. A cabin noise level of less than 85 DB is recommended. The transport team should protect themselves against auditory nerve trauma by wearing ear protective devices.

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