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Case report

What is the right helicopter for air medical scene response?

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The use of rotary wing aviation for prehospital response has become popular; it is also frequently an emotive issue. There is an erroneous tendency to regard almost any helicopter as a potential air ambulance. This is akin to regarding every car in the small hatchback class or larger as a suitable road ambulance. In reality, some helicopters are manifestly unsuitable for the emergency medical service (EMS) role, and there is no aircraft ideal for every scenario [3,5].

Helicopter transportation is not intrinsically therapeutic. It is merely a tool, the value of which in trauma lies in being able to deliver the patient to definitive or more advanced care—or vice versa. As a rule helicopters are likely to be two to three times as fast as a speeding ambulance in most geography. However, in many instances the helicopter is responding to a call from an ambulance team already on scene. Hence, the helicopter transport time includes launch, outward flight, scene, and return flight times, plus any secondary transport time at both ends, and may be little or no faster than a road ambulance at getting the patient to hospital [9]. To shorten this interval would require responding a helicopter on receipt of every emergency call. Hence the value of helicopter transportation lies predominantly in its potential to provide a centrally based clinical team capable of instituting advanced measures at scene and/or in transit for a relatively small number of patients. In some systems, the successful use of very small helicopters to deliver advanced care teams and equipment to scene with subsequent patient transport by road has been reported [6]. However, in most situations, the expectation will be that the helicopter is also used to transport the patient; while in some situations of difficult access, helicopter transport may be the only option available.

It should be borne in mind that the only patients for whom helicopters have been shown to be beneficial are those with serious blunt trauma: injury severity score (ISS) >9. This is the same group in which hospital based teams capable of instituting advanced trauma life support (ATLS®) measures have also been shown to be of benefit (in situations where prehospital times are prolonged) [1,2,7,8]. So, assuming that: (a) tasking is appropriate; (b) patient transport is part of the requirement, then it can be assumed that institution and/or continuation of ATLS® measures will be required in the aircraft cabin. A suggested ideal cabin layout for such patients is shown in Fig. 1, while the specifications in Table 1 can be regarded as minimum standards for EMS helicopters. A patient stable enough to travel in an aircraft that does not meet these standards will almost never have a *medical* indication for helicopter transport. While there may be logistic advantages to helicopter transport of a stable patient, aircraft not meeting these standards should be reserved for such tasks only as problems will inevitably arise at some stage if sub-optimal aircraft (or crews) are utilised for critically injured patients.

Requirements are also influenced by the scope of missions the helicopter will be expected to perform. In some countries, such as Australia, air medical scene response has traditionally encompassed hoist rescue. This requires the aircraft to be a suitable platform for winching, including stretcher winching. This "raises the bar" in terms of aircraft payload, performance, features (e.g. sliding doors) and cost.

In addition, helicopters are often also (and quite appropriately) used for interhospital transport of the critically ill, of both trauma and medical patients. If the role of the helicopter service encompasses technologically specialised interhospital transports such as neonatal or balloon pump transfers, this will require a certain minimum floor-space that may dictate a larger aircraft.

For trauma the arbitrary distinction between scene and interhospital transport on occasions becomes blurred—e.g. a severely injured patient taken to a small local district hospital while awaiting the arrival of the helicopter. The clinical approach to such a patient is essentially the same whether the helicopter lands at the scene or at a small hospital with minimum capabilities; the service should be prepared, staffed and equipped to respond to the trauma patient at whatever location is appropriate in the circumstances.

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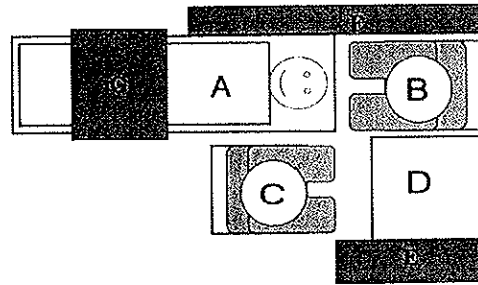

[A] Patient stretcher. [B] Primary patient attendant – in airway control position.

[C] Secondary patient attendant – has hand/eye/voice contact with (B).

[D] Worktable/equipment stowage cabinet or bins – accessible to both medical crew.

[E/F/G] Options for medical equipment location (monitors, ventilator, etc) : (E) – Roof or wall mounted above worktable; (F) – wall/door mounted alongside/above patient; (G) - Stretcher bridge system, or roof mounted above patient.

(N.B. Patient can be either head forward or aft. This configuration can also be mirror image.)

Fig. 1. Suggested ideal cabin configuration for EMS helicopters.

Table 1
Minimum medical specifications for EMS helicopters

1	Fitted with at least one appropriate stretcher
2	Seating for an advanced care team of at least two with seats at the head and side of the patient (see Fig. 1)
3	Main and portable oxygen and suction systems
4	Fitted with mobile intensive care equipment, preferably in detachable modular form, including: ventilator with disconnect alarm; pulse oximetry, capnography, blood pressure and ECG monitoring; and infusion pumps
5	Equipped with a full range of ATLS drugs, fluids and supplies, with safe and accessible in-cabin storage
6	Defibrillator certified for in-flight use
7	Overhead IV hooks (minimum of 2)
8	Appropriate lighting for cabin configuration/hours of operation
9	Hands-free communication system for medical crew headsets, with capability to isolate from flight crew
10	Appropriate emergency service radios, plus integrated cellular telephone (with latter able to be used by medical crew)

In light of the above criteria currently used helicopters can be broadly categorised into four classes, as shown in Table 2.

Class I aircraft (4–5 seaters) have, as expected, cabin floor space equivalent to a small/medium car. They are unsuitable for the air medical role, except for delivery of teams, and transport of seated patients or minor injury stretcher cases only.

Class II represents the "entry level" aircraft—capable of carrying a single stretcher and two attendants, with an acceptable cabin layout, albeit one which usually requires part of the stretcher to be within the cockpit, in place of the co-pilot's (left front) seat. They have been widely used for transport of serious or critical patients, they require some compromises in their medical fit and most have limited access to the patient in flight. They also place the patient in

Table 2
Classification of potential EMS helicopter types

Class I: light single engined 4–5 seaters; approximately 1600–1900 kg maximum all up weight	Class II: light utility single or twin 6–7 seaters; approximately 2000–2500 kg maximum all up weight	Class III: executive light-medium twins, 7–8 seaters; 2500–3500 kg maximum all up weight	Class IV: medium twins, transport category 8–11 seaters; 3500–6000 kg maximum all up weight
Bell 206 Jet Ranger	Bell 206L Long Ranger series	Agusta A109 series	Agusta–Bell AB139 (in development)
Eurocopter EC120	Bell 407/427	Agusta A119 (single)	Bell 412 (and earlier 212) series
Hughes/MD500–600 series	Eurocopter AS350–355 series	Bell 222–230 series	Bell 430
Robinson R44	Eurocopter EC130	MBB/Eurocopter BK117 and EC145	Eurocopter AS365/EC155 "Dauphin"
	Eurocopter (MBB) BO105 series	Eurocopter EC135	Sikorsky S76
		MD900 Explorer	

close proximity to the flight controls—a potential significant risk if carrying confused or uncooperative patients. Ideally they should be operated only with a skilled clinical team able to perform pre-emptive procedures to minimise in-flight incidents and interventions. They are also difficult to optimise for multiple roles—and may require pre-flight reconfiguring for different missions. Most are single engined, the exception being the MBB (now Eurocopter) BO105 series; but some single engined types also have an optional twin engined variant—e.g. Aerospatiale's (now also Eurocopter) AS350 "Squirrel" and AS355 "Twin Squirrel"; and Bell's 407 and 427 models. This is significant because twin engines may be mandatory in some operating jurisdictions (see later).

Class III are probably now the most widely used air medical craft. What distinguishes them from the Class II in this categorisation is having longer cabins with (at least partial) functional separation of cabin and cockpit. All Class III craft can accommodate the cabin configuration shown in Fig. 1 to comfortably carry a single critical patient. Most can carry a second stretcher, or a third medical crewmember, but not usually both. As might be expected there are variations between types in areas such as loading, seating arrangements, power margins, speed, range, instrument flight (IFR) capability and winching performance that may influence choice for a particular service. All are twins, except the A119 Koala, a single engined development of the A109 series.

Class IV aircraft are the largest commonly used in civil air medical transport. All can comfortably carry multiple patients and medical team members, and are IFR capable as a rule. However, they are expensive to purchase and operate, and are over-specified for the majority of scene flights (which in most systems are overwhelmingly for a single patient only). Furthermore, their increased downwash and rotor diameter can create problems when landing at scene.

There are a number of other factors that may influence choice of aircraft.

1. *Door layout*: Most aircraft load through side doors, and this requires swivelling the stretcher. Some (e.g. BK117, EC135) can load patients straight in through rear "clamshell" doors beneath the tailboom, which may reduce lifting effort for crew and emergency services personnel at scene, but conversely may also require some or all team members to stoop during loading. Side loading may be made easier by pivoting stretcher carriers, but this may carry a penalty in both weight and increased loading height.
2. *Stretcher requirements*: Larger or rear loading aircraft in particular may have the ability to accept a wider range of stretchers, which may include standard ambulance trolleys/gurneys. Using stretchers interchangeable with road ambulances can make for easier turnarounds at scene. However, use of large gurneys rather than typical aeromedical litters may compromise cabin space—such as preventing seating at the head of the patient, or restricting even large aircraft to carrying a single stretcher only.
3. *Sliding doors*: Some types of helicopters have sliding cabin doors standard, while most other types can have them fitted either as factory options or aftermarket kits with supplemental type certification (STC). At least one sliding door is essential for winching operations. Sliding doors can also be opened during approach to scene landings and enable crewmembers to assist the pilot with hazard identification and clearances, with obvious safety benefits. Use of this capability is obviously dependant on having medical crew trained in this aspect of cockpit resource management and airmanship.
4. *Undercarriage type*: Depending on model, helicopters have either wheeled or more commonly skid landing gear. A few models offer a choice of either—e.g. Bell 222 series, while some skidded models have a choice of high or low skids. Wheeled helicopters may be at an advantage when operating from airports (although few EMS helicopters do), as they can ground taxi, and they are easier to wheel in and out of hangars. In some situations, a triangular wheeled undercarriage may be more stable on uneven ground than a pair of skids. However, the latter tend to have a larger "footprint" and create lower ground loading, making them more suitable for landing on soft surfaces. Generally aircraft on skids sit higher than those on wheels. As a rule, lower cabin deck heights make for easier stretcher loading. However, a low cabin deck tends also to mean lower fuselage clearance over terrain obstacles. This is a significant hazard for EMS helicopters regularly landing on uneven ground; and may be exacerbated by protrusions such as radio aerials and "NiteSun" type searchlights usually mounted beneath the cabin. It may also mean a lower main rotor clearance.
5. *Rotor clearance*: All other things being equal, the higher the main rotor clearance the better. A high main rotor offers greater safety margins for personnel, as well as reducing the chance of terrain strike or foreign object damage. The most dangerous phase of operations is during start-up and shutdown when the rotor blades may flex down to lower than normal levels. This is particularly true with older two bladed "teetering head" rotor designs—e.g. Bell Longranger and 222–230 series. All commonly used EMS helicopters have a single main rotor system and therefore require an anti-torque device. With the exception of the McDonnell Douglas MD900 with its unique NOTAR fan system, all other helicopters use either a conventional or an enclosed "fenestron" tail rotor. NOTAR and fenestron systems and high mounted conventional tail rotors may all offer benefits both in safety for personnel and defence against foreign object damage. Again, however, none of the technological variations are as important in safety as having well trained and safety conscious aircrew and ground EMS personnel.
6. *Speed*: Intuitively, faster helicopters might be expected to be better. However, the fastest aircraft (e.g. Sikorsky S76

and Agusta 109) also tend to have low rotor clearances, especially at the front, which is conventionally the safe zone for approaching a helicopter with engines running. Also, not all fast helicopters have good hover performance, which is especially important in hoist operations. Furthermore, as most scene flights are relatively short, cruise speed may be less important than rapid launch in determining response times—and smaller less complex aircraft tend to have faster start-ups and hence quicker launch times. A more capable clinical crew has been shown to have far more influence on survival than faster aircraft [10].

7. *Twin engines*: Twin-engined helicopters might be expected to be superior to singles from the safety standpoint, but accident statistics fail to confirm this. The commonest cause of air medical accidents is wire/tree strikes during scene landings—for which twin engines provide no additional safety. The best use of two engines may still be two air medical helicopters. An example of this is the A119 Koala, which compares well with its twin-engine older siblings and other Class III craft in speed, range and cabin space; at significantly lower operating costs. However, legislation in a number of jurisdictions, such as the Joint Aviation Regulations (JAR Ops 3) in Europe may restrict air medical operations to twins.
8. *Instrument flight capability*: Depending on weather and scope of operations, IFR capable aircraft may confer a safety benefit. In the event of inadvertent entry into non-visual conditions (i.e. cloud) an IFR capable aircraft and crew can transition to instruments and climb, where a visual (VFR) flight only operation will be compelled to try and descend out of cloud—an inherently risky procedure.
9. *Seating*: As above, minimum seating (for a single patient) should be for two medical attendants, ideally in the layout shown in Fig. 1. A third seat enables carriage of an additional medical team member, an observer, or a crewmember in training and (appropriately located) is a prerequisite for double patient transports; while even a fourth may be desirable (see later).
10. *Patient capacity*: The capacity to take a second patient is theoretically desirable but infrequently required. Two critical patients require a minimum of three medical crewmembers: a primary attendant for each patient and a shared assistant. Most helicopters smaller than those in Class IV cannot take both a second patient and a third attendant. Most Class III craft can carry one critical patient, or two non-critical stretcher cases, or (some models only) one of each. As outlined above, helicopter transport of non-critical patients is normally only for logistical rather than medical reasons. It may be that other imperatives, such as hoist capabilities, or the need to carry balloon pumps or neonatal capsules and extra crew, may have already dictated a Class IV helicopter. If not, the decision to "up-spec" into this class should only be taken after careful assessment of the projected number of two patient missions that cannot be completed with assistance from other EMS helicopters or road ambulances, or by sequential transport.

In summary, choosing an air medical helicopter is a complex procedure. Above a certain minimum standard, choice is based on a variety of factors, including total mission profile, and (by no means least) cost. It is likely that the choice of aircraft is less important than the choice of appropriately skilled medical and aviation crew with a strong safety culture to achieve an effective and safe EMS helicopter operation.

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