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Memorandum
Department of Planning and Development
Planning Division

To: Chair Lowry and Members of the Portland Planning Board

From: Rick Seeley, Senior Planner, GPCOG

Date: January 14, 2005

Re: January 18, 2005 Planning Board Workshop
Maine Medical Center Contract Zone
(Building Addition, Helipad, Parking Garage, and Central Utility Plant
Vicinity of Bramhall, Charles, Wescott, Ellsworth, Crescent, Gilman and Congress Streets)

Report of Dr. Steven Thomas

In response to concerns expressed by the Neighborhood Council in meetings with Maine Medical Center during the fall, the City retained an independent emergency medicine clinician, Dr. Steven H. Thomas, MD, MPH to assess and comment on several questions related to the clinical need for the proposed helipad.

Dr. Thomas's, final *Report to the City of Portland: Helicopter transport into Maine Medical Center,* dated December 17, 2004, is attached to this memo, along with Dr. Thomas' resume.

Dr. Thomas has agreed to attend the January 18th Planning Board workshop to present the results of his work and to respond to questions.

Revised Draft Conditional Zone Agreement

Since the January 11th Planning Board workshop, City staff and the applicant have been working to revise the draft Agreement in response to comments and concerns raised at the workshop. The latest revision will be available on Tuesday.

Attachment: Report from Dr. Thomas, MD, MPH

Report to the City of Portland:

Helicopter transport into Maine Medical Center

Stephen H. Thomas MD MPH

17 December 2004

Contents

Executive summary

The consultant was charged with assisting the helipad debate by means of assessment and commentary upon the following major points:

1) helicopter triage guidelines currently used to determine who needs air transport by Life Flight of Maine (LFOM) to Maine Medical Center (MMC);
2) clinical and logistic circumstances associated with the current "bifurcated" system (of LFOM transport into Portland Jetport, followed by ground transport to MMC);
3) consideration, based upon review of a series of LFOM-MMC transports, of relative merits of replacing bifurcated transport with transport to an on-site MMC helipad;
4) determination, based upon review of a sample of LFOM transports to MMC, as to the proportion of LFOM patients who could be safely triaged *away* from landing at any on-site MMC helipad, instead using the bifurcated transport model

There were other charges to the consultant. Comment was to be provided on subjects such as mechanisms of benefit associated with use of helicopter Emergency Medical Services (HEMS), clinical and logistical courses of patients in the pre-transport time frame (*i.e.* at trauma scenes or referring hospitals), and helicopter safety concerns. These issues are addressed in the body of the consultant's report, but are excluded from this summary page.

The consultant's work commenced with identification of a study sample of 100 consecutive LFOM-MMC transports. Clinical and logistics information relevant to these patients was obtained by reviewing records at both LFOM and MMC. Data gathering continued with review of LFOM policies and procedures. As needed, the consultant contacted other individuals in the field in order to benefit from their expertise in areas pertinent to bifurcated transport and HEMS safety.

Given the broad scope of the work assigned to the consultant, and the importance of providing supporting evidence for the consultant's statements, this report's conclusions are not easily encapsulated. With the *caveat* that some important details are excluded in a short summary, the consultant's major conclusions comprise the remainder of this one-page abstract.

Most importantly, the consultant concludes that LFOM patients coming into MMC are of notably high acuity, in large part because the currently used triage rules in are reasonable and consistent with national guidelines. There is no reason to suspect there will be major changes in the HEMS triage guidelines, on either the local or national fronts, in the foreseeable future.

The high LFOM acuity contributed heavily to the consultant's opinion that risks associated with Jetport-to-MMC bifurcated transport were concerning. It is left to the City of Portland to adjudicate "acceptable risk." But the consultant's considered decision is that it is highly unlikely there is a prospectively identifiable (*i.e.* at transport time) patient subset of any significant size, in which bifurcated transport could comfortably replace use of an available on-site MMC pad.

Overview of scope of report

As dictated by the City of Portland, with advice from parties interested in the issue at hand, this report addresses multiple facets of the question of helicopter EMS (HEMS) transports into MMC. The main discussions in this report cover:

1) Assessment of the criteria used to determine air *vs.* ground triage for transports into MMC, with concentration on the questions:
   - Is there consistency between the "local" guidelines (*i.e.*, those dictating HEMS triage for flights into MMC) and generally accepted national guidelines?
   - What is the likelihood that national (and/or local) guidelines will change in such fashion as to lower the threshold for HEMS transports into MMC?
   - Is there currently in place at LFOM, an internal review mechanism for provision of utilization review for helicopter use appropriateness?
2) Review of a consecutive series of HEMS transports into MMC, to:
   - Determine whether air transport triage is being conducted in a manner consistent with the local guidelines;
   - Assess, in a set of actual patient transports, the timing and other process variables associated with the current system of landing at the Jetport and utilizing a ground transport vehicle to MMC; and
   - Adjudicate whether any clinical deterioration (or significant risk thereof) occurred in association with the ground transport leg (from Jetport-to-MMC).
3) Description of consultant-performed "mock run" ground vehicle transports to MMC, as executed from the Jetport and also from the new Mercy Hospital site to the MMC
4) Consideration of safety issues pertinent to the possible on-site location of the MMC pad

The report is divided into sections. The first section following this overview is an introduction to the subject of HEMS and its possible benefits, to both patients and EMS systems.

Introduction and background: HEMS benefits to patients and regions

Air medical transport, as provided by HEMS, has been used in the civilian medical setting since the 1970s. Currently, expert sources estimate that there are 400-450 helicopters providing up to 250,000 transports annually in the U.S.[1] While this report does not intend to focus on the evidence supporting use of helicopter transport in this country, some background information on HEMS and its salutary effects provides a useful framework for the discussion as to the proposed Maine Medical Center (MMC) on-site helipad.

The growth of HEMS has been accompanied by increasing scrutiny as to potential benefits accrued by this resource-intensive intervention. General reviews of the HEMS literature[2-4] have concluded that the weight of evidence supports contentions of outcomes benefits from use of air medical transport. Perhaps more relevant to the situation in Maine and the City of Portland, studies have identified significant mortality reduction associated with HEMS use in nearby urban New England (Boston)[5] and in more distant areas (notably Georgia and Oregon) with more rural demography that approximates the Maine situation.[6,7] Notably, the papers dealing with HEMS and outcomes benefits do not deal solely with trauma. In one study with geographical parallel to the southern Maine setting, HEMS dispatch to non-trauma "stroke scenes" was used in the Florida/Georgia border region to improve patient access to timely provision of advanced stroke care.[8]

When considering whether, and for which patients, HEMS should utilize an on-site hospital helipad, a brief overview of HEMS benefits is helpful. It is important to consider not only benefits to individual patients, but also benefits accrued to the regions served by HEMS.

HEMS benefits to patients

Mortality seems like the most obvious potential patient benefit upon which to focus, and in fact survival improvement has been the main endpoint of most of the major HEMS studies. This is probably because mortality is relatively easy to address in the types of large, retrospective study designs comprising most of the HEMS outcomes literature. Due to the relatively low number of patients for whom HEMS can *definitively* be shown to save lives, studies lacking large numbers tend to have insufficient statistical power to demonstrate a HEMS outcome effect.

Morbidity improvement (*e.g.* better neurological outcome) as a clinical study endpoint has the attraction of being easier to test, since fewer patients must be enrolled to find this more frequent outcome (as compared with mortality). By definition, however, nonmortality HEMS-associated benefits which have been demonstrated – improved pain care,[9] better pediatric[10] and adult[11] endotracheal intubation and airway management, more streamlined access to time-critical cardiac[11] or neurologic[8,13] care – are somewhat less compelling than "saved lives." On the other hand, nonmortality endpoints such as better airway management can provide clues to mechanisms by which HEMS use results in outcomes improvement.

HEMS and regional benefits

Some of the above-mentioned HEMS mortality/morbidity advantages (*e.g.* faster transport of patients with cardiac or trauma to definitive care) have clear relevance to the question of on-site helipad landing at MMC. Also, any intervention that helps individual patients, should also be considered on the positive side of the EMS regional ledger. More specifically to regional issues, there are additional HEMS-associated advantages with particular applicability in areas of Maine-like population density.

As an example of a HEMS advantage with high relevance to southern Maine, HEMS may be the best means for getting advanced-level prehospital care (ALS) to patients in relatively remote regions. On first impression, getting ALS care to patients in remote areas seems to have very little relevance to MMC's helipad, since the issue deals with getting the helicopter and crew to the patient, not getting the patient to the hospital. Upon further consideration, however, there *are* aspects of this regional HEMS benefit with applicability to the MMC helipad question. To wit, patients could incur ALS access delay and outcome detriment, if LFOM is called for initial ALS response and helicopter liftoff is delayed due to getting flight crews back to the Portland Jetport from MMC. Theoretically, LFOM could be delayed in responding, in a manner that would not occur if LFOM were using an on-site MMC helipad, due to crew nonavailability related to their being occupied on the ground leg between the Jetport and MMC. How likely is occurrence of such a scenario? An idea of the relative scarcity - but not absence - of LFOM response delay due to the aircraft/crew being already occupied, can be gleaned from reviewing a set of LFOM transports. For this and for other reasons mentioned elsewhere in this report, a review of records was performed by the consultant. The review entailed detailed reading of both the LFOM and MMC medical records of a consecutive set of 100 LFOM-MMC air transports during a period from 12/2003 through 7/2004.

Based upon the review of records, HEMS delays due to helicopter nonavailability appear to be uncommon in Maine. Nevertheless, when delays have occurred they can be potentially critical. For example, one cardiac patient was to be transported from a community hospital to the MMC cardiac cath lab for emergency coronary care. There was a 37-minute lag between the initial LFOM call and subsequent helicopter dispatch, which was due to the LFOM aircraft being occupied with other transports.

HEMS nonavailability due to having the aircraft and crew busy on other worthy transports can hardly be criticized. Less defensible would be a HEMS response delay due to time lost from having flight crews' needing to make ground transit legs between the MMC and the Portland Jetport. While the scenario of delayed LFOM response, attributable to the ground transport leg and preventable with use of an on-site MMC pad, would not be expected to occur commonly, the example is telling. Importantly, the concepts of regional HEMS benefits, and regional "risks" of HEMS nonavailability for rapid response, illustrate that some risks incurred with the bifurcated transport model are not obvious, and that regional EMS systems considerations should weight in the decision as to whether an on-site MMC helipad is used. Use of a bifurcated transport model not only places the current patient undergoing transport at potential risk, as outlined in some other sections of this report, but there is the additional consideration that the extra transport time can cause risk to *other* patients in the region, who may have urgent need for a helicopter.

Given the time-criticality of many HEMS missions for scene trauma, a ground transport-associated HEMS response delay of even half-hour can have significant effects. As a specific clinical example, airway management serves well. Intubation (placement of a breathing tube in the trachea for ventilatory support) in the field by *ground* ambulance providers has been correlated with *increased* patient mortality, but the same data have demonstrated that airway management by *HEMS* crews – who have higher success rates than ground EMS providers[22] – *decreases* mortality.[23,24] Delays in LFOM response to a trauma scene associated with the air medical crew being "tied up" on Jetport-MMC ground transport, could range from as little as a few minutes to over a half-hour (as might be the case if LFOM is called for a scene transport just after commencing a ground transport leg into MMC). If these delays are of sufficient magnitude that airway management must be deferred for a longer period, or perhaps performed by less well-equipped and less proficient ground EMS providers, there is potential for significant impact due to need for a Jetport-MMC ground transport leg.

There is another system-related benefit to HEMS, which has applicability to the MMC helipad debate. Regionalization of specialty care has improved trauma outcomes, and there is growing confirmation that it improves outcomes in other patients (*e.g.* cardiac, neurologic).[8,12,13] One of the tenets upon which regionalization rests is rapid transport of patients for interventions such as trauma surgery, cardiac catheterization, or stroke treatment. All of these interventions are necessarily time-critical. It follows that a central goal of any medical center striving to provide regionally unique, time-sensitive care, is to streamline the access to that care. It is important to emphasize that this issue is being addressed *not* from any type of marketing perspective (*i.e.* for MMC), but rather from the distinct clinical perspective of having an excellent institution optimize ability to serve its patient population with maximum efficiency and efficacy.

In summing the association between HEMS and individual patient as well as regional care, it is important to keep in mind, that HEMS is intended to transport the most critically ill and injured patients. For others who need MMC care, ground transport will remain the best mechanism for getting to tertiary care. For patients with time-critical need to get to the "referral center," for either diagnostic or therapeutic (or both) reasons, the individual case – and the EMS system and region as a whole – is more likely than not to benefit from elimination of an extra transport leg. The potential advantage of eliminating the Jetport-to-MMC leg is multifold, as will be discussed in subsequent sections of this report.

Subsequent sections of this report address HEMS benefit mechanisms and cover logistics of the MMC bifurcated transport system. The goal is to keep in focus the fact that the best solution to this and other healthcare discussions, is the one that optimizes chances for favorable patient outcome – and by extension improves healthcare for the region as a whole.

HEMS transport speed and out-of-hospital time

When advantages of helicopter transport are considered, one of the first points to arise is the concept of speed. The speed of the helicopter allows the advanced life support crew to arrive at the patient quicker, provides a region with rapid-response advanced care coverage using a limited number of vehicles, and may get the patient to definitive care faster. These are all important advantages that may be accrued with use of HEMS. However, there is more to the "speed" story.

Some of air transport's time-associated benefits, which are due to minimizing out-of-hospital time, are gained even in the absence of HEMS getting the patient to tertiary care faster than ground transport. This aspect of the HEMS advantage to patients has no small relevance to the MMC situation.

In some patients – especially those who are in tenuous condition or who may require difficult interventions in the event of clinical deterioration – the minimization of time spent in the relatively uncontrolled out-of-hospital transport environment is an admirable goal. Expert commentators have long stated that "interhospital transport is not without risk."[28] This section of the report will address some facets of transport risk, and develop the idea that transport should minimize the time spent in the out-of-hospital setting.

It is well known, and consistent with common sense, that a myriad of interventions from airway management[14,15] to advanced life support tasks[16] to chest compressions for CPR,[17,18] are simply more difficult to perform in the out-of-hospital (air or ground) transport vehicle than they are in the controlled setting of the hospital. While transport equipment is of admirable quality, even optimally-functioning prehospital equipment may fail to detect abnormalities (*e.g.* cardiac dysrhythmias) easily found in the hospital environment.[19] Furthermore, equipment malfunctions seem to occur more frequently in the transport setting; such problems are also more difficult to "fix" outside of the hospital.[19]

To move to specific clinical scenarios, one easily understood situation in which out-of-hospital time is best minimized is the case of a pregnant patient. Given the complicated pregnancies characterizing interhospital transports, and the resultant desire to minimize chances of an out-of-hospital delivery, a rapid helicopter flight is quite preferable to use of a ground vehicle. Since some referring hospitals may have ready access to ground transport vehicles, it is possible that ground transport could be *started* (if not completed) faster than would be achieved with a helicopter. For example, if the helicopter is 20 minutes away, and a ground unit is ready to embark on short notice, it is possible that despite the helicopter's greater speed, the ground transport option would get the patient to the receiving center in a similar time frame. In such cases, helicopter transport could still be preferable; the out-of-hospital time can be relevant even when the overall "transport time" is similar between ground and air transport options.

There were many cases identified in the LFOM-MMC review, in which the minimization of out-of-hospital time was important. A few illustrative examples are informative. One patient, who had respiratory disease, was receiving a certain mode of advanced ventilatory support at the referring hospital. She had to be taken off of this advanced ventilation mode during transport, due to inability to provide the intervention in the out-of-hospital setting; in such a case the absolute minimization of out-of-hospital time was of obvious import.

In another case demonstrating the importance of minimizing out-of-hospital times, a patient had a severe electrolyte abnormality. The patient had the cardiac conduction delays which can be seen with such an problems, and had a pacemaker in place during transport. The transport pacemaker was external transcutaneous device – a type which often fails to capture and control the heartbeat in patients such as the one in question. Failure of the external device to capture requires placement of an internal (transvenous) pacemaker. While a relatively easy job in the hospital setting, internal pacer placement is simply not an option in the field. Thus, it is important to minimize the out-of-hospital time for patients like this one, in whom pacemaker capture failure can translate to the need for CPR.

The intent of this section's discussion is to demonstrate that speed issues are relevant in more ways than the obvious. Even if a patient gets to the hospital in the same amount of time via ground or air transport (*i.e.* if ground transport is able to leave the referring hospital much sooner than HEMS would), in some instances the need for HEMS is driven by the desire to minimize time spent in the less-safe transport setting. Depending on the clinical scenario at hand, the out-of-hospital time issue can have direct relevance to determinations of whether patients should be flown to an on-site helipad at MMC. In trying to ascertain the clinical impact of prolonging out-of-hospital time with a Jetport-to-MMC ground leg, the next step for this report is to characterize the timing of this extra transport leg.

Characterizing the ground transport leg from Jetport to MMC

This section will provide statistical summary of the time incurred by LFOM using the bifurcated system of transport to MMC. For the series of 100 LFOM-MMC transports reviewed, reliable data on the time for the ground leg were available for 36 cases. The mean (average) time was 16.9 minutes (standard deviation, 4.9). The statistical 95% confidence interval for the mean was 15.2 to 18.5 minutes. The median ground leg transport time was 16 minutes (interquartile range, 12.5 to 20.0 minutes); 99% of the ground legs were achieved within the range of 10-30 minutes.

Though there was a lot of missing data, careful review of the applicable information renders highly unlikely any association between presence of transport time data and significantly shorter (or longer) length of ground leg time. In other words, there seems to be no "selection bias" in terms of which ground transport runs had the times recorded. The consultant believes that the time estimate of 15-16 minutes accurately reflects the time required to offload patients at the Jetport and get them to MMC.

Patient transfers during HEMS transport

Apart from the time issues associated with bifurcated transport, another component of risk that must be considered is that which is incurred by the extra physical movement of the patient (*i.e.*, jostling while moving from stretchers to ambulances, and during the ambulance ride). To quantify as much as possible the extent of this potential for patient shifting and movement, the consultant performed a "dry run" from the Jetport to MMC. It was found that the Jetport-to-MMC transit involves a number of steps and two extra patient movements. Considering the high acuity of the LFOM patients comprising the study sample of 100 patients, general use of on-site MMC landings would, in the consultant's opinion, be significantly advantageous as compared to a bifurcated transport model.

The patient transfer issue, taken in consideration with the acuity of the LFOM-MMC cohort, is core to the consultant's judgment that nearly all patients undergoing HEMS transport into MMC would stand to benefit from on-site landing. Development of this theme is the focus of the rest of this section of the report.

A large proportion of patients transported by LFOM have been intubated; that is, they have breathing tube and are undergoing artificial ventilation. In the sample of 100 cases reviewed, 18% of patients were intubated (95% statistical confidence interval: 11% to 26.9%). Intubated patients tend to be of sufficient acuity that they benefit most from expedited transport; for that reason alone these patients should be transported directly to the Level I center (without an extra transport leg) if possible. However, even apart from time considerations, the act of moving intubated patients incurs risk. One complication reported due to moving intubated patients is development of ventilator-associated pneumonia, which appears to be caused by jarring and displacement of ventilator tubes.[27] Furthermore, the fact that patients must often be manually ventilated (*i.e.* "bagged") during transfers entails risk of over- or underventilation and attendant complications. Consistent ventilation synchrony (*i.e.* matching of assisted breaths with patients' spontaneous breathing efforts) is very difficult to maintain during manual ventilation; asynchrony markedly increases the patient's work of breathing.[20] Other problems with manual ventilation include inconsistent positive pressure and potential for worsening blood oxygenation for a given percentage of inspired oxygen.[20] Attendant changes in blood oxygenation are often sufficiently severe to incur substantial risk of low blood pressure, cardiac dysrhythmia, or both.[21]

Other issues may also arise related to ground transport and patient transfers. These risks have been well-delineated in the realm of both intra- and interhospital transport; either setting serves to demonstrate the advantage in minimizing patient transfers. Risks identified in previous clinical studies[29-31] include, but are not limited to: inadvertent discontinuation of blood pressure support drug infusions (with resultant hypotension), loss or infiltration of intravenous lines, repositioning-associated changes in patient comfort (with associated pain-caused physiologic sequelae), accidental dislodgment of endotracheal tubes, displacement of fractures with associated pain and bleeding, movement of surgical drains, and disconnection of cardiac monitoring leads. Furthermore, even in the absence of any dislodgments or equipment-specific issues, it is known that positional changes tend to effect changes in cardiac output and respiratory mechanics.[32] These movement-associated adverse events, clinically significant in terms of both morbidity and mortality,[29] have been shown to occur even when trained personnel are accompanying, and paying close heed to, the patient being transported.[30]

Relevant to the MMC helipad question - which should not be distracted by consideration of rarely occurring risks - are findings that mishaps have been found to occur in as many as a *third* of transports of critically ill patients, and that problems tend to occur during patient movement from one stretcher over to another.[30] Thus, there are clinically important risks associated with even a single unnecessary patient transfer - such as would occur with any ground transport leg after LFOM landing in Portland.

In addition to intubated patients, another population both comprised a large proportion of the LFOM-MMC sample and is also at particular risk from transfers. Pediatric patients, which constituted a fourth of the LFOM-MMC study set of 100 transports, are known to be particularly vulnerable to problems occurring during transfer. This makes common sense to anyone involved with pediatric trauma or critical care, but there is also evidence basis for concerns. Problems with oxygenation and ventilation, as well as inadequate fracture immobilization and resultant displacement and pain, have been noteworthy in studies of pediatric patients.[31]

By this point, the reader could be forgiven for wondering if the risks associated with patient transfer are being a exaggerated for effect. In fact, out-of-hospital care is indeed a potentially dangerous business - especially when the patients undergoing transport are of the acuity found in the LFOM-MMC group. Unfortunately, the risks of moving patients are imperfectly understood even by most healthcare providers. Physicians and others who do not actively participate in day-to-day care of critically ill and injured patients tend to be undereducated as to level of risk associated with patient transfer, even when the transfers" occur within the hospital environment. The sobering truth is that, as one expert reviewer has concluded, at major hospitals about one patient per month suffers cardiac arrest or death from transport-related complications.[33] Thus, patient transport should not be taken lightly, as there are potential risks in just about all who undergo this activity. Selected cases will illustrate the applicability of patient transfer concerns in those individuals being flown into Portland.

There were at least three patients with spine injuries (among other problems). In patients such as these, transport time is a critical parameter of interest for this report. Just as critical, though, is the need for minimization of patient movements, since the "conversion" of spine injuries from incomplete (or even asymptomatic) to devastating is a real risk. The importance of minimizing jostling is also illustrated in the case of a patient who had a rather severe spine injury. The LFOM crew documented their special precautions to prevent further displacement and neurological injury during their transfers of this patient; the success of those precautions does not negate the desirability, in future cases, of minimizing transfers in such patients.

Other instances where the actual movement of patients poses high risk are easy to find in the LFOM-MMC transport series. In patients who have suffered certain types of trauma, the extra two transfers associated with the Jetport-to-MMC ground leg clearly incur nontrivial risk (*i.e.* for further injury, such as the risk associated with transfer of at least one trauma patient in the series of reviewed transports). In another example, a patient who had undergone a temporizing surgical procedure was at risk, due to the potential for complications associated with moving patients who have had such procedures. In these cases, it was important to minimize both out-of-hospital time and also transfers.

Inadvertent traction on both medical and nonmedical instruments and objects is an obvious area of patient transfer risk. There are other instances, less easily explained but nonetheless familiar to prehospital and in-hospital providers, where patient deterioration is associated with the simple act of movement. As an example, one patient suffered a precipitous blood oxygenation drop (pulse oximetry falling to 80% instead of normal >97%) concomitant with movement from the referring hospital stretcher to the LFOM stretcher. No deterioration occurred during the subsequent movements of transferring this patient, but seasoned clinicians would not discount as coincidence the temporal association of transfer and deterioration.

This section of the consultant's report has attempted to portray the only-too-real risks which are incurred by moving critically ill and injured patients from one place to another. Clearly, the transport of such patients to regional facilities such as MMC is, on balance, in the best interests of patient outcome. However, the transport-associated risks outlined in this section should make a case that a plan for getting patients to tertiary care centers, should best incorporate all possible mechanisms to render their movement between facilities as safe as possible. Since the patient sample reviewed for LFOM flights into MMC is of high acuity, this population is a good target for efforts at elimination of unnecessary movements and transfers.

Clinical deteriorations occurring in the 100-transport sample of Jetport-MMC ground legs

Much of the previous sections' discussion has focused on risks, rather than actual untoward clinical events, associated with the Jetport-to-MMC ground transport leg. To some degree, a considered judgment about appropriateness of bifurcated transport should focus on those risks, rather than actual untoward events. This is because the risks, as previously discussed, are based upon clinical knowledge and research; risks and probabilities are more generalizable to future operations than are single occurrences which may never be repeated. Assessment of risks in a large group also avoids some of the subjectivity inherent to retrospective assignment of adverse outcomes. It is not easy to know which patients who did poorly, had suboptimal outcomes due to the extra time or jostling of the ground transport leg. Conversely, no one can, with absolute certainty, aver that any patients who did poorly, did so only because of ground transport.

With the above *caveat*, if analysis of a reasonably large set of LFOM-MMC transports fails to identify any clinical consequences occurring during, or associated with, ground transport, then the likelihood of frequent adverse events from ground transport would seem to be less than that implied by previous sections' discussion. Thus, this section of the consultant's report will address instances in which adverse clinical events – ranging from vomiting to cardiac arrest – happened during the ground transport leg of patient transports between the Jetport and MMC.

One patient had been stable, both neurologically and by vital signs, since before LFOM was called to the referring hospital, where this patient had a neurologic diagnosis. There were no problems during the air transport leg, but during the 20-minute ground transport leg (from 1922 to 1942) the patient suffered significant deterioration (disorientation, speech problems, and lethargy). Upon arriving at MMC, the patient underwent emergency ventriculostomy (to relieve brain pressure) after a computed tomography (CAT) scan.

Another trauma patient, was diagnosed at a community hospital as having both neurologic and spine injuries. He was stable during the air transport leg, but during the ground transport from the Jetport he began yelling and became very agitated (with concomitant increases in intracranial pressure, in addition to potential disruption of his spine injury). Similarly, another trauma patient became very drowsy during the ground transport leg (indicating neurological deterioration, likely from increased intracranial pressure). Increases in intracranial pressure, which are well known to have adverse outcomes in the head-injured patient, also occurred with near-certainty in another trauma patient, who did fine during the air transport leg but who was "bucking the ventilator" (*i.e.* fighting mechanical ventilation) during ground transport.

One trauma patient was noted to have neck vein distension, decreasing breath sounds, and increasing respiratory rate (from 18 to 38 breaths per minute) during the ground transport from the Jetport. These findings strongly suggest collapsed lung. Due to the proximity to MMC when the patient worsened (the ground leg took 12 minutes from 1328 to 1340), no interventions were performed during the ground transport. However, it is clear that had the ground leg been longer, or the LFOM crew more aggressive, the lack of definitive diagnostic interventions – such as X-ray – in the ambulance would have resulted in the patient undergoing temporizing treatment for a collapsed lung (needle thoracostomy). The needle thoracostomy, which involves placement of a needle catheter in the chest to release air from a collapsed lung, would have been painful to the patient and would have necessitated (as do any and all needle thoracostomies) placement of a chest tube. Since this patient was quickly found on chest X-ray at MMC to *not* have the collapsed lung that his clinical signs so strongly suggested, he avoided these procedures. In this case, needle thoracostomy performed during the ground transport *would have been appropriate*, given the clinical circumstances, but it would have translated into a surgical procedure (chest tube placement), significant pain, and many days in the hospital that would have been avoided by having LFOM land on-site at MMC.

In another case, a patient with bleeding did not appear to have significant instability at the referring hospital, but the patient developed low blood pressures during the LFOM air transport leg. The blood pressures stabilized during the air transport leg (there were normotensive blood pressures during final 24 minutes of flight). During the 11-minute interval between the Jetport landing (2159) and loading onto the ground ambulance at 2210 (by which time the patient would likely would have been in or near the operating room given an on-site landing at MMC), the patient rebled and significantly deteriorated such that by 2221 the patient was receiving medications for slow heart rate.

In another case, a patient suffered two logistics-type complications associated with the ground transport leg. First, the battery on the mechanical ventilator became depleted – a complication known to incur substantial clinical risk[19] – and the patient subsequently required manual ventilation. Manual ventilation is less desirable for a number of reasons that are well characterized in the critical care transport literature; these problems have clear applicability to this patient, given her history of severe pulmonary hypertension.[20,21] The second logistics problem in this patient was a delay in the commencement of the ground transport leg. This was due to the need to remix more of the patient's infusion therapy; a remixture which would have been obviated if LFOM had landed on-site at MMC.

The mechanical ventilator battery problem arose again, during the ground transport leg in another patient, resulting in the need for LFOM crew to perform manual (bag-valve) ventilation, with its less effective and more problematic profile (as compared to mechanical ventilation). As an even more concerning problem, the switchover to manual ventilation in this patient – who had suspected sepsis – resulted in unnecessary exposure of the crew to the infectious agent with which this patient ultimately was diagnosed.

In an example of severe, yet unexpected, deterioration occurring during ground transport, a patient who was stable at a referring institution, and had no instability by either complaints or vital signs during air transport. Approximately 11 minutes into a 16-minute ground transport from the Jetport to MMC, the patient's respirations suddenly decreased and the patient became near-comatose; the patient required assisted ventilations during the final minutes of the ground transport and required emergency intubation at MMC. This patient provides evidence of the real-life difficulty of any system which attempts to "triage" patients away from an on-site helipad to bifurcated transport.

As another sample case, a patient had vomiting at the end of the air transport leg. The patient vomited again during the ground transport, with the latest episode of vomiting being bloody. This complication has relevance to bleeding risk during the emergency cardiac cath lab procedure this patient underwent at MMC (since catheterization lab drugs include large doses of potent anti-clotting medication).

Another patient had a decrease in blood pressure just after landing at the Jetport. This patient improved with medications given just after the aircraft landed, but deteriorated after being loaded into the ground ambulance. (If the patient had been landed at an on-site helipad at MMC, the patient would have been in the MMC operating room by the time his condition deteriorated.) This patient's systolic blood pressure dropped to 40 (normal: 120), and by the time the 16-minute ground transport to MMC was completed the patient was in full arrest. This patient's chances of survival were significantly and adversely impacted by the bifurcated transport.

Another patient with a bleeding problem, was receiving a blood transfusion to help balance ongoing hemorrhage. The blood transfusion was completed soon after LFOM landed at the Jetport. During the ground transport leg, which began at 2031, the patient's blood pressure dropped first to 98 (at 2035) and then to a near-arrest level of 55 (at 2040). This patient's vital organ perfusion was clearly compromised at a time when the patient would have been in the operating room if the aircraft had landed at an on-site MMC pad.

Another patient had vomiting during the ground transport leg of the patient's interfacility transfer to MMC's cath lab. This patient had had no nausea or vomiting during air transport. Vomiting is very uncomfortable for the patient, causes anxiety and sympathetic nervous system outflow (not good for patients in the throes of a heart attack), and is associated with the risk of aspiration of gastric contents into the lung. It would appear that avoidance of vomiting may be insufficient reason for triage away from bifurcated transport, but it is not easy to decide in which patients nausea and vomiting risk is "acceptable" if they are of the acuity seen in the reviewed

LFOM-MMC sample.

Another case involved a trauma patient with an unusual piece of equipment in place for transport. There were no problems during the air transport, but a potentially life-threatening problem developed during ground transport. The patient had to undergo a "rescue" procedure in the ambulance during a 13-minute Jetport-to-MMC leg.

In short, this section has outlined clinically significant complications in 14 cases, or 14% of the transports (statistical 95% confidence interval, 8-22%). Importantly, this calculation does *not* include patients with acute illness (*e.g.* heart attack) or injury (*e.g.* brain trauma) for whom prolonged transport associated with the ground leg posed additional risks due to time-criticality of disease (see next section).

Time criticality in the sample set of Jetport-MMC ground transports

Previous sections of this report have addressed overt patient deteriorations occurring during the ground transport leg, and it is the opinion of the consultant that the types of deteriorations that were identified are in the range of "expected" sequelae from bifurcated transport. There is another part of the "deterioration" issue that deserves emphasis, however: patients who are of high illness and acuity simply have better chances at good outcome, if they get to the receiving center more expeditiously. Irrespective of the ability to objectively measure the precise impact of an added 15-20 minutes on patient outcome, the fact is that patients of the nature of those reviewed in the LFOM-MMC cohort are precisely those in whom an extra few minutes can be lifesaving or otherwise critical.

Clinicians have long known that, for trauma, there is an initial period of about an hour (Dr. R. Adams Cowley's so-called "golden hour") during which evaluation and interventions tend to be particularly critical to outcome. Equally certain is the clinical basis for the adage, as applied to patients having heart attacks, that "time is myocardium" (heart muscle). Neurologists providing cutting-edge stroke care have modified the statement to "time is brain." Patients with a variety of other medical conditions, ranging from sepsis to toxicology and overdose situations, stand to benefit from streamlined delivery to tertiary care.

While there can be little argument that patients with acute trauma, heart attacks, strokes, and other obviously time-critical diagnoses should benefit from rapid transport, it is not easy to ascertain any specific adverse events associated with delays incurred by employing a Jetport-to-MMC ground transport leg. There are, to be sure, some instances – which were *not* included in the above sections' outlining of ground transport deterioration events – where ground transport and the attendant delays more likely than not had adverse effects. For example, one patient had worsening of chest pain (due to an acute heart attack) during the final 10 minutes of air transport. Worsening pain directly correlates with dying and "at-risk" (ischemic) heart muscle, so it is obvious that what this patient needed was immediate heart catheterization – which he indeed received, after a delay of 20 minutes incurred for ground transport.

There is no way to know how much more heart muscle was lost due to ground transport time in any given patient, such as any of those urgent cardiac cases (9 in all) involving transport directly to the MMC cardiac catheterization suite. However, as every physician involved with cardiac care knows, a 20-minute delay in getting a patient to the cath lab can have profound impact upon survival and also on non-mortality endpoints (*e.g.* amount of heart muscle lost).

The imprecision of measuring transport- and time-related adverse effects does not mitigate the undesirability of prolonging transport in cases such as that of cardiac patients. Similarly, neither the consultant nor anyone else can say with absolute certainty what extra minutes' ground transport time meant to ICU lengths-of-stay, organ damage complications, neurologic outcomes, or a host of other outcomes endpoints in patients in the LFOM-MMC transport group. However, there is at least one mechanism of focusing the question, and that is to assess patients who received time-critical interventions upon arriving at MMC.

Medical and surgical interventions were often provided immediately upon patient arrival at MMC. Some illustrative cases will clarify the point of time-criticality. One patient had a persistent heart rate above 200 beats per minute, despite about a dozen drug administrations; this patient was successfully converted to a normal heart rhythm by a cardiologist within minutes of MMC arrival. Another patient suffered complete respiratory collapse at the time of arrival at MMC; this patient was immediately intubated for ventilatory support. Another patient underwent an emergency neurosurgical procedure upon MMC arrival. In another case, a patient with a bleeding problem and alteration in the ability to form blood clots (coagulopathy) underwent immediate MMC interventions that included urgent correction of the blood clotting abnormality.

This section has attempted to show that, even in the absence of overt deterioration, patients in the LFOM-MMC cohort tended to have clinical situations in which time was critical. In such patients, lack of deterioration doesn't imply that the patients in question would not have benefited significantly from elimination of the ground transport leg from the Jetport to the MMC facility. The main basis for this opinion of the consultant, and the primary foundation for the consultant's consistent judgment that patients in the LFOM-MMC sample would have been better served by an on-site helipad, lies in patient acuity. The next section of this report addresses the acuity of LFOM transports, with focus on how patients are "selected" for helicopter transport, and on the processes designed to insure appropriateness of helicopter use (utilization review).

Patient acuity, triage, and utilization review at LFOM

One of the charges for the consultant was to assess the HEMS-transported patients for overall acuity, with the goal of determining whether LFOM helicopter triage guidelines were consistent with national guidelines. Additionally, the consultant was asked to comment on the likelihood that there would be national (or local) guidelines changes resulting in significant alterations in air transport utilization. In other words, a question was: How likely is that air medical transports into MMC will increase due to major changes in nationally utilized helicopter use guidelines? This section addresses those issues, and also touches upon the question of whether frequency of HEMS use is likely to increase if an on-site pad is constructed at MMC.

The "national helicopter triage guidelines" used were the most recent, and most evidence-based (*i.e.* founded on the available clinical and scientific research) air transport guidelines available. Published in 2003,[25] these guidelines (which are reproduced in Appendix II of this report) have been endorsed by the National Association of EMS Physicians (NAEMSP), the Air Medical Physician Association (AMPA), and the Association of Air Medical Services (AAMS). The national guidelines were promulgated by the NAEMSP Air Medical Services Committee, and the process of developing and writing the guidelines took the better part of three years. There has been no new evidence widening the scope of air medical transport in the time period since 2003, when the NAEMSP guidelines were published. The consultant can state, to a reasonable degree of certainty, that it is highly unlikely any major changes in the guidelines will occur in the next few years. Major changes after that time period are also unlikely – the literature supporting the first set of guidelines was 20+ years in the making – but any modifications will of course be driven by scientific evidence from clinical studies.

Notably, the consultant was not able, at the time of this report, to collect transport numbers data from a similar area (to Portland) which transitioned from bifurcated transport, to an on-site helipad. One area of potential similarity (Albany Medical Center in New York) was identified, as having transitioned from an off-site to on-site helipad years ago, but that program was not able to provide exact numbers on transport volume. The program's director did indicate that their HEMS service's gradual and modest increase in transport volume did not appear to be affected by the transition from off-site to on-site helipad.[45] In short, the consultant does not believe, based upon his experience with either the triage guidelines or with other programs that utilize on-site pads, that construction of an on-site MMC pad is likely to result in burgeoning numbers of HEMS transports.

The aim of the national triage guidelines is to provide an overview of circumstances in which helicopter use, as compared with ground transportation, is the most appropriate mechanism for getting patients to high-level care. In the case of MMC, ground critical care transport is readily available. The presence of the alternative transport mode means that patients who need to get to MMC, but in whom illness or injury isn't time-critical, can use the ground transport vehicle. The main goal of such ground vehicle utilization is to reserve helicopter assets in order to maximize their availability for truly needy patients. In terms of relevance to the MMC situation, the ground critical care capabilities mean that the average patient who *does* come into MMC by air, is of relatively high acuity.

Contributing to the high relative acuity of air transported patients into MMC is the fact that regional hospitals (*e.g.* Central Maine Medical Center, Eastern Maine Medical Center) serve to "filter out" less critical patients, transferring to MMC (often by air) those patients whose needs outstrip the capabilities of the regional hospitals. As an example of the exception proving the rule, one patient was transported to MMC from a scene after a skiing incident. The patient was initially scheduled to go to another hospital by air, but operating room unavailability at that hospital prompted aircraft diversion to MMC. The point with relevance to the MMC on-site helipad issue, is that patients from further distances (from MMC), whose acuity places them at lower relative risk from birfurcated transport, aren't transported to MMC. Rather, these patients go through a filtering process whereby initial evaluation at referring hospitals receiving the initial air transports (*e.g.* CMMC, EMMC) selects out only the most acute illnesses and injuries for flight into Portland. The end result of this process is that patients transported by air into MMC tend to be, even when compared with other air transports, on the higher end of the acuity scale.

In reviewing the LFOM transports in the set of 100 LFOM-MMC patients, it was clear that LFOM was indeed adhering to its stated triage guidelines, which are represented in Appendix I of this report. Furthermore, the review of details of the LFOM guidelines reveals that they are consistent with the helicopter utilization guidelines promulgated by national authorities.[25] There was no evidence that the LFOM helicopter utilization guidelines were either more or less stringent, than the general accepted parameters for use of helicopter transport.

Reasonable guidelines for LFOM helicopter utilization do not necessarily translate into 100% "appropriate" use. As can be seen, the guidelines are fairly complicated, and it is important to remember that in the state of Maine, helicopter dispatch can be activated by a wide variety of nonmedical personnel (*e.g.* ski area workers, remote woodland corporate entities) that would be expected to be more likely than trained paramedics to "overutilize" the resource. Thus, it is vital that an *a posteriori* "utilization review" occur on an ongoing basis, to insure that the use of the helicopter resource is occurring in a manner consistent with the local (LFOM) and national guidelines.

Upon reviewing LFOM policies and procedures, the consultant has found that there is indeed an ongoing utilization review process. In fact, each flight is reviewed by a physician director and there are feedback loops which help inform and educate referring agencies as appropriate. While an on-site review of LFOM documents was sufficient to convince the consultant of the fact that LFOM post-flight appropriateness review processes were up to national standards, it is more important to note that pertinent LFOM policies have been approved by the national Committee on Accreditation of Medical Transport Systems (CAMTS).

CAMTS accreditation is the highest goal for U.S. air medical transport services, and cannot be achieved unless a given program demonstrates proficiency and efficiency in a wide variety of medical, procedural, and safety parameters; not least among these is the requirement for ongoing utilization review and feedback.[37] As a CAMTS-certified program, LFOM is required to demonstrate that the program follows both the letter and spirit of the rule requiring ongoing utilization review. Specifically, LFOM must perform "a structured, periodic review of transports (to determine transport appropriateness or that the mode of transport enhances medical outcome, safety, or cost-effectiveness over other modes of transport) performed at least semi-annually and resulting in a written report."[37]

During the charges to the consultant, one question that arose was: "Should there be some independent ongoing utilization review of LFOM flights into MMC?" The consultant believes that, *objectively* speaking, the LFOM processes currently in place are sufficient. (This assumes there is ongoing updating and maintenance of LFOM standards to match national guidelines; such would be evidenced by LFOM maintaining its CAMTS accreditation.)

Despite the consultant's belief that adding an additional layer of "independent" utilization review is administratively and medically unnecessary, the Portland helipad debate seems sufficiently vigorous that – in the event an on-site MMC helipad is constructed – some period of ongoing review may be helpful. A truly independent reviewer (assuming one could be easily found and agreed upon) could help assuage fears of inappropriate use of an MMC helipad facility. The arguments *against* institution of such additional review hinge upon both the costs (in time and other resources) of redundant review, and the low likelihood that such a system would identify problems missed by the extant process. The decision is of course left to the City of Portland, but the salient points seem to be: 1) LFOM triage protocols are consistent with national guidelines, 2) LFOM transports as reviewed by the consultant are executed in line with LFOM triage protocols, and 3) there is an appropriate and national-standard quality assurance and utilization review mechanism already in place.

This section has addressed some of the putative explanations for LFOM's high patient acuity, and additionally has made a case that changes in the currently used triage guidelines are likely to be minor in the foreseeable future. Furthermore, it appears unlikely to the consultant that construction of an on-site MMC helipad would add significantly to the current transport volume profile of LFOM into MMC. The next sections address what actually appears to happen, during a "mock transport" from various locations to the MMC.

Mock transports

The mock transports were executed so that the consultant could get a first-hand sense of what was entailed in the various possibilities for getting air-transported patients into MMC. They are necessarily subjective, with some estimates of time that may not be precise, but the general information obtained was of substantial value to the consultant, and may be illuminating to the reader of this report.

Mock transport from Jetport to MMC

To familiarize the consultant with the current logistics of the ground transport leg, a "mock run" from the Portland Jetport to the MMC was executed at approximately 1500 on a weekday (11/18). This time was selected because it correlated with the time that appeared to correlate with the highest volume of LFOM-MMC transports.

Upon landing at the Jetport, the helicopter waits 2-3 minutes for the engines to "spool down." LFOM does not engage in hot-offloading, which is the practice of removing the patient to a ground ambulance while the rotor blades are still turning. Hot-offloading of patients is uncommonly indicated, and incurs a greater risk to ground personnel than does the alternative of "cold-offloading" (after the rotors have stopped turning). Conversations with LFOM personnel indicate that hot-offloading is "not an option" with Jetport transports, due to its being disallowed by the personnel (Medcu) providing ground transport. For the vast majority of cases, landing of LFOM at an on-site MMC pad will not save the few minutes required by the practice of cold-offloading; however, it is conceivable that with appropriate training the use of an on-site MMC pad can offer the *potential* to utilize hot-offloading in highly time-critical cases.

Subsequent to patient unloading from the helicopter, the patient is placed onto a transport stretcher, rolled to the ambulance, and loaded into the ground vehicle. In combination with the subsequent need for post-ground leg transfer to the hospital stretcher, the current ground transport system thus entails *two* patient transfers: one to the ground ambulance, and another to the hospital stretcher at MMC. (This compares unfavorably to the on-site MMC pad system's single transfer onto a hospital stretcher from the rooftop pad.)

After the patient is loaded into the ground transfer ambulance, the ground vehicle must leave the security-controlled area of the airport. This step, which requires an attendant to open a locked gate, usually takes negligible time. However, LFOM crew indicate that on occasion, there is a wait to get the gate opened. For example, in one patient with severe bleeding, there was an 8-minute time lapse between Jetport landing and commencement of ground transport to MMC. The LFOM record notes that 6 minutes were required to get the patient into the ground ambulance, and a 2-minute delay was incurred to "get going" (which was later translated by LFOM personnel as indicating problems getting through the gate).

After the ground ambulance clears the security zone of the Jetport, there is a turn onto the road towards MMC. This turn, by the consultant's count, is the first of *nine* 90-degree turns that the ground ambulance makes during its journey to MMC. Depending on the clinical situation, these turns and the associated patient movement risk can pose as much, or even more, patient safety (and discomfort from pain or nausea) concern as the actual time required for the ground transport leg. The MMC drive also entails passage through many traffic lights (twelve, by the consultant's rough count) and a stop sign. Even if these "obstacles" do not force stoppage of the ambulance, there is an expected change in smoothness of transport vehicle's transit which can pose additional issues ranging from nausea to vehicle motion-related technical problems.

During the consultant's "dry run," the time elapsed between departing the Jetport and arriving at MMC was 15 minutes. Since this 15 minutes was driving time only, and didn't take into account the time (usually about 3-5 minutes) required for patient offloading from the helicopter and loading into the ambulance, this time is shorter than that calculated from the available records from LFOM-MMC (see section on ground transport times). Given the fact that the time (as compared with the consultant's timing run) "lost" by transferring the patient is "gained" by Medcu running with lights and sirens to MMC, the consultant's calculated time of 15 minutes is consistent with what would be predicted based upon the available information.

Mock transport from Mercy (new site)

To familiarize the consultant with the potential logistics of a ground transport leg from the new Mercy Hospital site (near the river, on the same side of the railroad tracks as is MMC), a "mock run" from the site to the MMC was executed at approximately 1300 on a weekday (11/20). Upon landing at the Mercy site, the helicopter waits 2-3 minutes for the engines to "spool down." It is not anticipated that the option of "hot-offloading" would be a possibility at a non-MMC facility, but this cannot be ascertained without doubt. Subsequent to patient unloading from the helicopter, the patient is placed onto a transport stretcher, rolled to the ambulance, and loaded into the ground vehicle. Notably, the use of the ground ambulance, instead of a (MMC) hospital stretcher, to receive the patient from the helicopter results in the same two-transfer need that the Jetport bifurcated system entails.

After the patient is loaded into the ground transfer ambulance, the ground vehicle departs for MMC (without any potential delays due to airport-related security gates). After the ground ambulance turns left (during the consultant's mock run, from a driveway near Redlon & Johnson company, onto St. John street), there is a short drive to Congress street. At Congress, the ground vehicle will turn right and continue on to MMC.

The mock run from the proposed Mercy site entailed five 90-degree turns. Two traffic lights were in the pathway. Having been calculated in a run in which the traffic lights were green, the consultant's estimated "new Mercy"-to-MMC transit of about 3 minutes probably approximates fairly closely, the "real-life" transport time between those two sites. To this three minutes should be added the expected time for engine spool-down and patient transfer to the ambulance, to achieve an expected total time (from helicopter landing to patient arrival at MMC) of about 8-9 minutes.

Mock transport from proposed rooftop helipad

The aircraft will land on the rooftop of a parking garage. Subsequent to patient unloading from the helicopter (see discussion above, covering hot- vs. cold-offloads), the patient is placed onto a rolling hospital stretcher (important: a single patient transfer rather than two). An elevator (dedicated to LFOM use when the aircraft arrives) will take the patient down about 20 feet (2 levels of the parking garage), after which time the patient must traverse a distance of about 100 feet (over a street). This is achieved in a closed and air-conditioned/heated hallway, after which a right turn brings the patient to the operating suite, or a left turn brings the patient into the Emergency Department. There is a dedicated CT scanner in the ED (which has relevance to certain types of emergent cases such as strokes).

Since the helipad and related structures are not built, times estimated for this transport system are estimated. Assuming a cold-offload and a ready elevator, it would appear that the total time elapsed between landing and patient arrival in the E.D. (or OR), would tend toward 4-5 minutes. Perhaps more importantly, at least for the sake of comparison against logistics setups involving ground ambulance legs, elapsed times could be assessed as the interval commencing with patient loading onto the first stretcher (transport stretcher for ground ambulances, hospital stretcher for on-site MMC transports) after helicopter landing. By this adjudication, the patient could be in the MMC ED/OR within 1-2 minutes after being offloaded from the aircraft.

Use of an acuity or time-of-day dependent helipad triage system

The crux of the issue confronting the City of Portland appears *not* to be whether an on-site MMC pad would be good for some patients, but instead whether such a landing area would be necessary for *all* patients. The current system uses a bifurcated approach, in which patients land at the Portland Jetport and subsequently undergo an additional trip in a ground vehicle. The issue of risks (from transfers and from time costs) associated with this extra transport leg have been outlined elsewhere in this report. It is not the intent of this section to reiterate arguments and impressions noted elsewhere. Rather, this section assumes that direct-to-MMC (on-site pad) transport *is* available and agreed-upon to be preferable for many HEMS patients; the section's goal is to consider whether bifurcated transport (*i.e.* as occurs now) should be maintained as an option for *some* patients (as defined by acuity or time-of-day).

One point to make is the that construction of an on-site MMC helipad would not, irregardless of any triage rules, completely eliminate the possibility of Jetport-MMC bifurcated transport. This is because weather considerations could occur, which would exclude flight into MMC but which would allow transport into the Jetport due to the latter's navigational advantages as an airport. This situation is not anticipated to occur commonly, but it is worth mentioning in any discussion about whether bifurcated transport should be "discontinued." The rarity of weather-dictated bifurcated transport is well-predicted, based upon the experience of other HEMS programs in New England: the fact of the matter is that when the weather is truly bad, no HEMS operations will occur (to the Jetport or to MMC).

If the system of bifurcated transport works now, and if it must be available for the rare case where weather allows helicopter operations but closes the MMC helipad, then why not have an approach whereby pre-flight screening determines the appropriate landing area? Such a triage system would, for example, come into play for nighttime operations where noise would be a particular consideration. For cases of lesser acuity, where there is lesser risk from patient transfers and time delays, it seems quite fair to pose the question as to why on-site MMC landing is really necessary.

If there is a helipad on-site at MMC, there would be only two reasons to triage patients away from landing at MMC and incur the extra resource expenditure and patient risks associated with use of the ground transport leg. These two reasons are safety and noise.

The issue of noise is addressed by another consultant's report. The issue of safety is covered in another section of this report, but some safety notes may be relevant here. If the weather is particularly bad, it may be safer to land aircraft at the Jetport, as noted above. Pilots routinely make this type of decision, and the certification of LFOM (which provides nearly all helicopter transports to MMC) by the Committee on Accreditation of Medical Transport Systems (CAMTS) demonstrates that program's demonstrated excellence in, and commitment to, safety issues which include pilot qualifications and training. Thus, for instances in which bifurcated transport is necessitated by weather/safety considerations, it is reasonable to believe that HEMS programs and pilots will exercise appropriate judgment. Other, closely related, safety-related information is found separately in this report in a subsequent section.

The critical reader may have noted the phrase, used on the previous page, "If the system of bifurcated transport works now." A rational philosophical objection to construction of a new helipad is: "If all patients currently go into the Jetport, do we *really* need to re-triage *all* patients to an on-site helipad?" In other words, where are all of the adverse medical outcomes ascribed to the ground transport leg?

As outlined in another section of this report, there *are* many adverse medical outcomes that have been associated with the ground transport leg. Rather than repeating clinical information previously iterated, the consultant will refer the reader to this report's sections discussing risks and deteriorations associated with the ground transport leg. The point is, the system "works" now, but it could clearly work better, for nearly all patients. The mere fact that a certain approach may be the best *current* solution does not translate to any certainty that there is not room for significant improvement.

Given the critical reminder that the opinion is based upon the consultant's review of LFOM-MMC transports revealing a clear pattern of high acuity, it is the consultant's judgment that transition to an on-site MMC helipad will effect substantial improvements to a system which is already good. As the major trauma center for Maine, MMC would do well to improve system care by offering the same expedited helicopter access as that which is now available at many other state facilities such as Eastern Maine Medical Center and Central Maine Medical Center. Given the high acuity of the trauma patients in the 100-patient sample, the consultant believes that transporting a trauma patient to the Jetport, if an on-site MMC pad were available, would not meet the standard of trauma care. Similarly, in virtually all cases of "scene" transport, trauma or otherwise, landing at an on-site MMC pad would be dictated both for considerations of trauma care, and due to the inevitable uncertainty underlying clinical knowledge about patients who haven't yet been evaluated by a physician.

If the idea of triaging trauma and scene patients away from an on-site pad isn't viable, the next step is to consider directing other (no trauma) patients away from rooftop. In this case also, the strong argument to maximize use of the on-site pad is based upon the imperfections of triage – imperfections that are not likely to go away any time soon. While a *retrospective* review can identify cases in which no adverse events occurred during ground transport, it is virtually impossible to predict, in a patient sample of the marked acuity of the LFOM-MMC cohort, which patients will be the unlucky ones. In some cases – trauma patients, those with ongoing chest pain from heart attacks – it is theoretically easy for a bifurcated system to triage the patient to the on-site hospital landing pad. Complications arise when it comes time to draw the line, and to determine which patients are "well enough" to *not* be at risk from the ground transport. (This doesn't even begin to consider the fact that provision of an infrequently utilized intervention – in this case ground transport – is associated with deterioration of the skills and expertise required to optimally perform that intervention.)

At the heart of the matter is the fact that for patients who aren't in obvious need of an on-site helipad, there is no triage mechanism possessing sufficient safety margin, that can be used to allow confident direction of the patient to the option of prolonged ground transport. The triage officer must have accurate information upon which to base a decision. However, any clinician who works in a tertiary hospital, and who has accepted patients in transfer, knows that – despite the best interests of community hospital providers – the patient that arrives at the Level I center may not bear much resemblance to the one described in the transfer conversation. This is not meant as an indictment on providers at referring hospitals, since patient situations change and diagnosis is still an inexact science. However, the relevance to the MMC helipad debate remains: regardless of the underlying explanation, any information given to a triage officer who is trying to figure which patients can go to the Jetport, should be viewed with healthy skepticism. For example, in a patient for whom LFOM transport was requested due to suspicion of a problem in the (noncerebral) vasculature, MMC specialists quickly realized the vascular problem had nothing to do the patient's problems; instead the patient was determined to have a stroke.

There is more to the triage difficulty argument than anecdotal stories (such as that of any of the previously mentioned LFOM-MMC patients) and the consultant's extensive experiences of patients arriving at tertiary care in quite different shape than that billed by transporting facilities. Clinical research demonstrates that patients undergoing interfacility transfer are inherently hard to characterize, and that they often are "sicker" than commonly used objective scores can measure.[35] The relevance to the MMC situation is: patients who appear to be "well enough" for bifurcated transfer may in fact have some of the other, more difficult to assess, characteristics associated with higher risk during transport. In a patient population in whom the acuity levels are low- or mid-range, the risks of triaging away from an on-site MMC pad are likely at a comfortable level. For the patients in the LFOM-MMC cohort, however, illness and injury acuity are sufficiently high that a reasonable and objective triage officer would rarely choose to incur the risks attendant to ground transport, when an on-site landing area is readily available. For example, to recall a previously noted case: patients can be stable in the ICU without any kind of deterioration occurring during air transport, but then, during the Jetport-to-MMC leg, they can suddenly become near-comatose with severe respiratory depression. This was a stable patient at another institution, who had passed the "test of time," for whom a "triage officer" could quite reasonably – and wrongly – denied access to an on-site MMC pad.

Since a system whereby triage to bifurcated transport is based upon injury acuity or other factors (such as time of day) appears less desirable than direct-to-hospital helicopter routing, the question arises as to whether such systems currently exist. The consultant being unaware of any such systems in the U.S., others with expertise were asked about whether they were familiar with a logistical model of the triage-to-bifurcated transport type.

HEMS services in the U.S. tend to be run by vendors that supply pilots and equipment to hospitals and other agencies running the HEMS service; the vendors bring aviation expertise to the partnership whereas the hospital personnel bring medical and transport expertise. The consultant contacted representatives from HEMS vendors, asking whether they were aware of any system whereby patients are triaged away from on-site helipads depending on clinical acuity or time of day.

The Director of Operations at one of the largest and oldest vendors, Keystone Flight Services which operates 35 helicopters flying from 28 locations in the U.S. Northeast, responded: "There are no Keystone contracts that I am aware of who have night restrictions on hospitals. This includes the receiving hospital helipads as well as the hospital helipads they take patients from."[38] The Vice President and General Manager of Keystone's Flight Services added: "To my knowledge we do not operate from any hospital heliports that are restricted from use at night."[39] Another vendor widely used in the U.S. is CJ Systems Aviation Group, which manages air medical services of 105 helicopters at 77 base sites. Their Director of Operations reported that: "I have not seen such a restriction in any of the programs we support."[40] Additionally, the Executive Director of the Association of Air Medical Services, to which organization nearly all American HEMS operators belong, answered: "I have not heard of any heliports operating under this kind of split/differentiated schedule."[41]

The consultant has been involved, to some degree, in situations at two locations in which the issue of bifurcated transport may be applicable. In the City of San Francisco, a helipad serving San Francisco General Hospital has been and remains the subject of intense debate, which involves a variety of issues including environmental impact, noise, safety, and even impact on overcrowded hospitals in the San Francisco area. (The consultant was involved in the process, to the extent of being asked to comment on medical importance of having an on-site helipad for a Level I Trauma Center.) While there are neighbors involved in the helipad process, with final hearings still pending, the Department of Public Health EMS authorities in San Francisco have "never considered a 'bifurcated' approach to landings." [44]

In another major city, much closer to Portland, a sort of bifurcated transport does exist, but the situation in New York City (specifically, Manhattan) offers few parallels to a plan for acuity- or time-of-day based triage of MMC patients away from an on-site helipad. First, and maybe most importantly, the issue in NYC is that helicopters – of *all* types, EMS and other – are not allowed to land on pads in Manhattan. This decision, which appears to be the result of a 1997 crash into the East River, of a Colgate-Palmolive corporate helicopter, is not likely to be modified given the occurrences of 9/11/01. The consultant, having served two visiting professorships in NYC, is familiar with some of the relevant issues. Of significance is the fact that in NYC, the helicopter "ban" applies only in Manhattan; a plentitude of Level I trauma centers in surrounding boroughs (and in New Jersey) translates into a rare need for HEMS transport directly into Manhattan island. Furthermore, there are no systems in place – to the knowledge of the consultant, or to others with experience with HEMS transport in New England and New York City,[42] – for differential triage to bifurcated versus on-site transport in NYC; indeed, the experts with whom the consultant spoke were of the impression that outside of rare/emergency contingency plans for landing in Central Park, there was *no* provision for HEMS to land at hospital sites in Manhattan.

Helipad sharing

The consultant was to report on any issues related to a system of helipad sharing, between MMC and Mercy Hospital. There is a new building site to which Mercy Hospital is relocating, and it is the consultant's understanding that Mercy has approval to construct an on-site helipad at their new location. The question which has been posed by participants in the MMC helipad debate is: Do we really need two helipads so close together?

If the patients comprising the LFOM-MMC transports were of lower acuity, then there could perhaps be reasonable argument in favor of a "shared helipad" system whereby MMC-bound patients land at Mercy and then undergo a relatively quick ground transport leg to MMC. With the acuity characterizing the LFOM study sample, however, the patient transfer issues mentioned elsewhere in this report come into play, even over a short-distance ground leg.

Given the axiom that *processes* (*e.g.* patient transfers) inherent to performance of a ground transport leg can represent as much of a threat to patients as do time delays, the consultant's judgment is that a shared Mercy helipad is not a good answer to get patients to MMC. Speaking from the perspective of medical appropriateness, it seems clear to the consultant that the overwhelming preponderance of patients, including all adult and pediatric trauma patients, would be using the shared helipad as a means to get to MMC – not Mercy. Considering the transport-associated risks as outlined elsewhere in this report, medical needs and risk assessments render untenable a "solution" in which the Jetport landing plan is exchanged for a plan to land in-town, at a non-trauma center hospital which by any calculation would receive a distinct minority of air medical transports. The consultant has not performed any clinical reviews of patients going to Mercy (though the facility seems to not receive HEMS transports on any regular basis), so the possibility of a shared helipad *at MMC*, with occasional transports of patients down the hill to Mercy, may indeed be feasible.

Safety considerations

As mentioned earlier in this report, safety is one of the theoretical foundations upon which to base concerns about an on-site MMC helipad. As noted, the particular safety profile of *current* HEMS operations in Maine (with LFOM expected to provide nearly all air transports into MMC's pad) is such that in the consultant's opinion, it is fair to assume that any HEMS helicopter landing at MMC's on-site pad, is maintained and piloted at the top of industry standards.

Before discussing just what the industry standards mean, it is worthwhile to digress and discuss what happens when a program operates *outside* the standards. Unfortunately, the people of Maine are only too aware of the risks. From the National Transportation Safety Board (NTSB) report BFO94FA013[36]:

> "On November 19, 1993, at 2039 Eastern Standard Time, a Bell 206-L-1, N911ME, landed hard during a forced landing touchdown in the Atlantic Ocean seven miles east of Portland International Jetport, Portland, Maine. The helicopter was owned by Airmed Skycare Inc of Portland, and operated by Echo Helicopter Inc. of Portland, Maine. Instrument meteorological conditions prevailed at the accident site. The certificated commercial pilot received serious injuries, while two of the three passengers were fatally injured. The third passenger has not been recovered and is presumed to be fatally injured. The helicopter was submerged in 85 feet of water and was destroyed. The flight was conducted under part 14 CFR 135. The medical evacuation flight originated in Ellsworth, Maine."

The NTSB report narrative continues on, to outline tragic consequences of a series of errors. From establishing a situation in which medical transport was profit-motivated, to having a pilot accept – and subsequently fail to abort – a mission for which he and his aircraft were unsuitable, the Casco Bay crash represents the worst of helicopter EMS operations. The inevitable question for the current debate is: Could it happen again in Maine? Most pertinent to the issue of MMC landing versus Jetport landing, the question is "Could the helicopter crash near its landing site and place nearby individuals at risk?

Despite having been involved in HEMS since 1990, the consultant is unaware of any instances of bystander (*i.e.* not crew or ground personnel) fatality incurred from a helicopter crashing at or near a hospital-based helipad. However, in an effort to maximize the chances of identifying such an instance, the consultant contacted the single individual whose name is most identified with HEMS safety: Dr. Ira Blumen of Chicago, the author of a comprehensive 70-page report addressing HEMS safety.[34]

The question directed to Dr. Blumen was: How likely is it that the helicopter could crash at or near the hospital's helipad, injuring or killing neighbors? Of course, Blumen's response was that we are dealing with probabilities, not absolutes, but the good news is that the probabilities are – while nonzero – extraordinarily low. In fact, despite decades' experience in HEMS, including research for preparation of his safety report published in 2002,[34] Dr. Blumen did not recall *any* instance in which a person not involved with the helicopter transport was killed in a crash. In his reply to the consultant, he indicated[26]:

> "I know of only one accident that killed "someone on the ground." On 1/22/2001 (Air Evac, based out of Quincy, IL) a security guard who was supposed to be securing the helipad during take-off walked into the tail rotor and was killed. There have been numerous helipad accidents (rooftop and ground), but I do not know of any others that injured/killed non-crewmembers or the patient."

No one's memory is perfect, and there may indeed have been some instances that are not recalled by the consultant or safety experts. However, it is difficult to dispute the contention that a HEMS aircraft crash killing someone on the ground is an extremely rare event. Furthermore, it is obvious that such a crash could occur at any time during flight (not necessarily at or near the helipad), so the theoretical protection offered by vectoring the helicopter away from an on-site MMC landing pad is outweighed (by at least an order of magnitude) by the patient benefits expected to be accrued from use of an on-site pad. When considering the low, but nonzero, likelihood of a helipad-related crash, it may be worth considering another event, also of low but nonzero risk: a Portland citizen has a prolonged wait for an ambulance, due to delayed EMS response attributable to resource occupation on a Jetport-MMC ground transport.

In summary, the consultant has informed the City of Portland that his expertise lies outside the realm of safety. However, using the best available resources, the consultant has attempted to illuminate the understandably resonant safety issue and paint a rational picture of extremely low – even difficult to quantify – risk levels. One program, LFOM, will be the near-exclusive user of the pad; their pilots will be familiar with the helipad and will be available to train any other pilots as they assume positions rendering them likely to land at MMC. (This sort of cross-training occurs quite commonly in HEMS in general, and in New England in particular; the Boston hospitals' rooftop helipads are used by six HEMS services.) Furthermore, accident-related issues such as mechanical and fire hazards will apply minimally, since no HEMS maintenance or even refueling will occur on-site at MMC. In short, safety considerations do not appear to be a rational basis for avoiding construction of an on-site helipad. As the San Francisco Department of Public Health report on their own helipad issue concluded, "There is little evidence to support any danger to surrounding neighborhoods, even though some of these neighborhoods would be subject to helicopter overflight."[43]

Conclusion

The consultant entered this process with a goal of assessing what HEMS transports into MMC *currently* look like, in order to provide commentary on what the best model for the future may be. If the HEMS resource would have been found to provide "convenience" transports, or even transports for purely logistical reasons (*e.g.* off of a mountaintop), the consultant was more than prepared to identify the transports as being of noncritical nature. However, for reasons outlined elsewhere in this report, the current system of helicopter triage in the state of Maine is such that LFOM is used appropriately, and in fact the patient acuity for LFOM transports rivals that of any program with which the consultant is familiar – from rural or urban areas.

There are clearly described risks associated with adding extra time and patient transfers onto the out-of-hospital transport of either scene or interfacility runs. Equally clear are the benefits associated with expedited transport into tertiary care centers, for a wide variety of medical and surgical patients. Unfortunately, while in retrospect (and with limitations inherent to attempts to adjudicate clinical cause and effect) some patients "would have been fine" with the additional ground transport leg, the consultant believes the LFOM-MMC transport sample evidence supports a conclusion that any acuity or time-of-day based system of triage *away* from an on-site helipad, to the Jetport for bifurcated transport, is undesirable when viewed from the standpoint of the patient being transported, and indeed the EMS system as a whole.

Having an on-site MMC helipad is reasonably certain to translate into better-quality care, in terms of maximizing chances for benefit and minimizing chances of risk, to the people of Maine who undergo air medical transport. The current system of bifurcated transport has not been a disservice to the population served by MMC, but the available data very clearly support an upgrading of the hospital's capability to expedite transport into its critical care areas. In just about every clinical system, including the one by which LFOM and MMC operate to get patients into MMC, there is room for improvement. Construction and regular use of an on-site helipad at MMC appears to exemplify such an improvement for the hospital, for LFOM, and for the patients.

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Appendix I: LFOM triage guidelines

LIFEFLIGHT OF MAINE
GUIDELINES FOR HELICOPTER TRANSPORT

GENERAL GUIDELINES

Many patients who require transport to centers with specialized or tertiary level resources are appropriate for transport by ground ambulance. A select group of patients may benefit from the advantages that helicopter transport can offer. These advantages include:

Decreased response time and length of transport
Availability of highly trained medical crews and specialized equipment
Increased access to tertiary and definitive care facilities when the patient requires specific or timely treatment which is not available at the referring hospital or facility

Even though the guidelines below are useful, they are not necessarily all-inclusive and should not replace decisions about transport based on sound medical judgement. It is likely that patients appropriate for helicopter transport would have medical conditions that fulfill one or more of the general criteria listed below, and would as well include one or more of the specific criteria, which follow. Some general criteria include:

- The patient requires critical care life support (monitoring, personnel, medications, or specific equipment) during transport that is not available from the local ground ambulance service.
- The patient's clinical condition requires that the time spent out of the hospital environment (in transport mode) be as short as possible.
- The potential for delays which may be associated with ground transport is likely to worsen the patient's clinical status.
- The patient is located in an area which is inaccessible to regular ground traffic.
- The use of local ground transport team would leave the local area without adequate EMS coverage.

SPECIFIC GUIDELINES

TRAUMA – Patient at Scene: Maine EMS Prehospital Trauma Triage Protocol

TRAUMA – Patient at Hospital:
Central Nervous System
Spinal cord injury or major vertebral injury
Head injury with one or more of the following:
Lateralizing signs
Penetrating injury or open fracture (with or without CSF leak)
Depressed skull fracture
Glasgow Coma Scale < 12 or deterioration GCS
For Scene Responses
Chest
Major chest wall injury
Wide mediastinum or other signs suggesting great vessel injury

Cardiac injury
Patients who may require prolonged ventilation
Pelvis
Unstable pelvic ring disruption
Open pelvic fracture
Unstable pelvic fracture with shock or other evidence of continuing hemorrhage
Major extremity injuries
Fracture/dislocation with loss of distal pulses
Open long-bone fractures
Extremity ischemia
Multiple system injury
Head injury combined with face, chest, abdominal or pelvic injury
Burns
with associated injuries
greater than 20% total body surface area
involving the respiratory system
involving face, head, feet, hands, or genitalia
electrical burns
Multiple long-bone fractures
Injury to more than two body regions
Secondary deterioration (late sequelae of trauma)
Respiratory failure with mechanical ventilation required
Sepsis
Single or multiple organ system failure (deterioration in central nervous, cardiac, pulmonary, hepatic, renal, or coagulation systems)
Major tissue necrosis
Comorbid Factors
Age <5 or >55 years
Known cardiorespiratory or metabolic disease
Pregnancy
Immunosuppression
Evidence of high energy impact
Death of occupant in same car

ADULT MEDICAL SURGICAL
Cardiac
Patients with cardiogenic shock (or requiring IABP)
Patients with acute MI & contraindications to lytic therapy who are candidates for emergent PTCA
High risk patients with failed thrombolytic therapy (large AMI, previous MI, previous CABG, severe ongoing ischemia) who are candidates for rescue PTCA
Life threatening medically refractory arrhythmias
Patients with medically refractory, unstable or post-infarct angina
Patients with suspected acute ventricular septal defects
Patients with rapidly decompensating valvular heart disease
Selected patients with cardiac tamponade and hemodynamic compromise
Patients with symptoms or signs of aortic dissection
Patients with the following conditions: acute pulmonary edema, cardiomyopathy, infectious

endocarditis, severe pulonary hypertension, hypertensive crisis, congenital heart disease or need for specialized pacemaker therapy

Patients requiring acute intervention (i.e., IV nitroglycerin, antidysrhythmics, thrombolytics, anticoagulants, PTCA, emergent cardiac catheterization, CABG, emergency cardiac surgery, or pericardiocentesis) unavailable at referring institution.

Other Medical/Surgical or Critical Care

Status post cardiopulmonary arrest with need for definitive management capabilities

Patients requiring continuous intravenous vasoactive medications or mechanical ventricular assist to maintain a stable cardiac output

Patients who may require mechanical ventilator support or are at risk of having an unstable airway

Acute pulmonary failure requiring sophisticated pulmonary intensive care

Acute ischemic event (extremities, intestinal) which requires urgent diagnostic procedures/treatment not available at referring facility

Dissecting, leaking, or ruptured thoracic/abdominal aneurysm

Acute cerebrovascular accident in evolution requiring therapy or diagnostic procedures not available at the referring institution

Gastrointestinal hemorrhage leading to hypoperfusion or requiring blood transfusion, angiography or other procedures not available at the referring institution

Unstable patient with renal failure requiring acute hemodialysis unavailable at the referring institution

Severe poisonings or overdoses requiring intensive care

Severe hypothermia or hyperthermia requiring immediate active therapy

Uncontrollable seizure activity

Decompression illness or carbon monoxide poisoning requiring hyperbaric oxygen therapy

Significant acidosis not responsive to initial therapy

Patients requiring emergency cardiothoracic, vascular or neurosurgical diagnostic or operative procedures unavailable at the referring institution

Complications of cancer and chemotherapy; opportunistic infections with unstable vital signs

Patients who have met the criteria for brain death and whose families have consented for organ donation when urgent transport is required for organ salvage

Patients receiving organ transplantation, when time frame of donor organ viability is extremely limited (i.e., heart, lung)

Transfer of time-sensitive transplant organ from procurement hospital to site of transplant

HIGH RISK OBSTETRICS

The majority of obstetrical patients are appropriately transported by ground ambulance; there are some, however, in whom timeliness of transport is especially important. LifeFlight of Maine is dedicated to the rapid and safe transport of high risk obstetric patients. Before consideration of air transport, there should be a very high probability that delivery will not occur during transport. If delivery is imminent or likely to occur during transport, alternate care plans should be considered.

General complications

Medical care immediately available to the patient is not optimal for the patient's actual or predicted obstetrical, medical or surgical complications

There is reasonable expectation that the birth of one or more infants may require obstetric or neonatal intensive care beyond the capabilities of the referring institution

The patient's obstetrical, medical or surgical problems require continuous attendance by trained personnel not available at the referring institution

Obstetrical complications

Active premature labor with or without rupture of membranes at less than 34 weeks, or fetal weight is estimated at less than 2,000 grams
Severe pre-eclampsia or eclampsia
Abruptio placentae or placenta previa
Third trimester bleeding
Fetal hydrop

Medical Complications

Infections which may cause premature birth
Severe organic heart disease
Renal disease with deteriorating function or increasing hypertension
Drug overdose
Collagen vascular disease, metabolic disease (e.g. hyperthyroidism), or any disease considered to exceed the resources of the referring institution
Miscellaneous unusual or severe illnesses

Surgical complications

Trauma requiring intensive care or surgical correction beyond the capabilities of local institutions, or trauma requiring procedures that may cause premature labor
Acute abdominal emergencies at less than 34 weeks gestation or with a baby whose estimated weight is less than 2,000 grams
Thoracic emergencies requiring intensive care or surgical correction
Neurosurgical emergencies such as intracranial hemorrhage, expanding pituitary tumor, or brain tumor
In general the following patients who are in labor should **NOT** be considered for air transport

multiparous patients:

cervix dilated 3-4 cm or more with active labor and a substantially effaced cervix
contractions less than 5 minutes apart
history of rapidly progressing labor

primiparous patients:

cervix dilated 4-5 cm or more with active labor
contractions less than 5 minutes apart

PEDIATRICS

Patient experiencing or has a high risk of developing cardiac dysrhythmias or cardiac pump failure that requires interventions not available at the referring institution.
Patient experiencing or has a high risk of developing acute respiratory failure or respiratory arrest and is not responsive to initial therapy
Patient requires invasive airway procedures (including endotracheal or nasotracheal intubation, tracheotomy or cricothyroidotomy) and assisted ventilation.
Patient with any of the following vital signs:
respiratory rate <10 or >60 breaths per minute
systolic blood pressure <60mm Hg in a neonate
systolic blood pressure <65mm Hg in an infant <2 years of age
systolic blood pressure <70mm Hg in a child 2-5 years of age or systolic blood pressure <80mm Hg in a child 6-12 years of age
Patient with any of the following clinical conditions:
near-drowning with signs of hypoxia or altered mental status
status epilepticus
acute bacterial meningitis
acute renal failure

poisonings and overdoses with hemodynamic or neurologic instability
Reye's syndrome
Hypothermia
Multiple trauma
GCS <12 or deterioration
Intensive care to intensive care transfer when ground transport time is >30 minutes
Vasoactive drip required to maintain BP
Arterial pH <7.2
Patients within 48 hours of respiratory/cardiac arrest
Non-trauma patient requiring cardiothoracic, neuro or pediatric surgeon for emergent care unavailable at referring institution

NEONATAL

Infant requiring mechanical ventilation or CPAP
Premature infant with gestational age <30 weeks and complications
Body weight <1500 grams and complications
Supplemental oxygen >60%
Neonate with extra-pulmonary air leak, interstitial emphysema, or pneumothorax
Need for transfer to Neonatal unit when ground transport time is >30 minutes
Cardiac or respiratory arrest within 24 hours
Temperature instability
Neonate requiring vasopressor drip medications or repeated volume challenges to maintain BP
Neonates with seizure activity, congestive heart failure, or disseminated intravascular coagulation
Surgical emergencies including diaphragmatic hernias, necrotizing enterocolitis, abdominal wall defect, intussusception, suspected volvulus, congenital heart defects

GENERAL EXCLUSIONS TO HELICOPTER TRANSPORT

Terminally ill patients, unless they have an acute correctable problem of an emergent nature
Patients in full arrest at the referring institution who cannot be stabilized to a perfusing circulation
Incessant VF or VT with severe hemodynamic compromise
Advance directives precluding aggressive life prolonging measures
Anoxic encephalopathy/coma