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'Virtual Presentation' During Interfacility Transport

Advances in science and engineering have made rapid transport from distant locations to tertiary medical centres the standard. Similarly, communication technology has changed the expectations for consultation or transmission of patient information en route. Nevertheless, a major Southeast Asia paediatric tertiary care centre, KK Women's and Children's Hospital (KKH) in Singapore, still receives patients with modest records and minimal physiologic monitoring from hundreds of miles away. The authors of a recent paper explore a vision that urges Paediatric Critical Care Transport to the next stage of development through 'virtual presentation' of the neonate or child patient.

A recent National Consensus Conference emphasised the changes which are occurring in paediatric and neonatal transport. Transport teams are becoming more ubiquitous and transport itself is taking on many characteristics of Intensive Care Unit (ICU) monitoring and care. However, this report also notes that there are few research studies on interfacility transport despite a strong trend toward delivering definitive care rather than merely relying on speed of transport. Beginning definitive care the moment the transport team arrives assumes the availability of specialty teams, highly trained and with equipment that mirrors that of the tertiary hospital care facility.

Now that it is understood that definitive care can and must begin and continue during transport, it is essential to expand the capabilities and participation of the transport team. It is understood as well that not all transport teams have the same specialty team composition or expertise. This is particularly true in more rural regions in the United States and in major medical centres which receive distant referrals from remote countries and regions in the most difficult of circumstances (such as KKH in Singapore). A system design is needed which is flexible and adaptable to many environments, levels of expertise and equipment configurations.

KKH Paediatric ICU - A Tertiary Referral Centre in Southeast Asia

The KKH referral region has expanded with time and transports now commonly cross great distances. Referrals arrive from different parts of the region such as Malaysia and Indonesia, and at times, from even farther away. The common means of transport is by air. Because of the distances and referral needs, there is the necessary practice of accepting the patient for distant transport and then relying on sorting out the difficult medical problems after the arrival of the team on the scene.

The common modern goals of transport -- to analyse the child's condition and begin treatments immediately -- are possible if technology is carefully integrated with available manpower and realisable expertise. In the future, neonates or children should not arrive with minimal documentation or fragmented understanding of physiologic responses to disease.

Situation Awareness

Researchers such as Brady have recently emphasised the importance of situation awareness in paediatrics and championed the use of in-hospital rapid response teams specially trained to intervene if a paediatric patient is thought to be deteriorating at their facility. Such teams have resulted in much better outcomes and fewer transfers to the ICU.

During critical care transport, transport teams often must address complicating diagnoses or clinical deterioration. It is usually not possible to place additional individuals on the transport team, or the critical care physicians on each transport mission. The solution is through engineering with techniques such as complexity reduction and information filtering to reduce information overload.

'Virtual Presentation'

What is needed is ‘Virtual Presentation’ of the neonate or child, a comprehensive interactive display that is shared between the KKH ICU experts on the ground and the transport team, in real-time and dynamically. This conception goes far beyond telemedicine and common video transmission. A virtual reality of the neonate or child would combine visuals, audio, along with physiologic profiling.

More monitors are needed for neonatal transport; the depth and frequency of physiologic measurement of the patient condition are required. By the time the neonate arrives at KKH, a complete physiologic picture and framework for actionable information display, integrated with ‘Virtual Presentation,’ should be available. This is a problem which haunts Emergency Medical Services in most locations, most situations, and for many diagnoses.

In-Flight Inflammatory Biomarkers

Still in the early stages of development, bedside measurements of cellular metabolism should be incorporated into the KKH expert model. In this way, cardiopulmonary physiology and its true effects at the cellular level should be continuously transmitted to paediatricians on the ground so that they can manage in-flight physiology in the most complex situations.

Inflammatory protein biomarkers have been demonstrated to be non-specific indicators of systemic inflammatory response to disease and injury. More recent work has shown that there are clear associations between cardiac events and the expressions of inflammatory biomarkers. As the patterns of biomarker expression are defined and accepted, biomarkers which may number in the dozens will be included in critical care transport; patterns of expression will help guide diagnosis, treatment pathways, and aid the definition of physiologic response.

Ultrasound and Elastography

A complete representation of the neonate or child during transport will require advanced visualisation technology. At present, large radiologic machines (computerised tomography or magnetic resonance imaging) cannot practically be provided during flight and transport. However, ultrasound can provide the technology required at this point to complete the rich definition of pathology and physiologic response.

Developments in ultrasound have been refined for such tasks as myocardial velocity imaging or the visualisation of deformation of the left ventricle. Elastography shows the dynamic change in tissue that occurs when stress is applied to the surface. Still in the early stages of clinical development, elastography has been applied to neurological and musculoskeletal conditions, and is evolving toward more difficult problems such as measuring hepatic stiffness, subsequently to other solid organs. Such information, combined and integrated with richer cardiovascular measurement, then transmitted simultaneously to ‘Virtual Presentation’ at KKH, would complete the vision of a unified system of patient, transport and distant expertise.

Conclusion

Paediatric Critical Care Transport requires a systematic solution empowered by engineering. As soon as a transport team arrives at a distant location, multiple sensors, monitors, haptic technology, and radiologic and diagnostic instruments must begin functioning in an integrated fashion. This system must be user-friendly for the overwhelmed transport crew, yet comprehensive enough for the distant KKH paediatric experts.

Communication in real-time and dynamic interaction with the neonate or child and transport team must be built into the design.

Rather than merely visual transmission as telemedicine, ‘Virtual Presentation’ of the neonate or child at a designated site at KKH would allow the virtual ‘hands-on’ management of the patient throughout flight. More monitors, a profound synthesis of physiologic information, integration with advances in ultrasound imaging and bedside protein and biomarker analytics, will yield a robust system for transport.

Difficulties with communication networks in such a configuration will be overcome, specified wireless networks designated and safety design and back-up incorporated. Vast computing power can be brought to the solution and treatment will actually begin as soon as the remote transport sets down to receive a patient.

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Published on : Sat, 6 Sep 2014