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Laboratory and Diagnostic Test Mobile Systems: Critical Issues and Perspectives in the Field of Major Disasters

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Introduction

Health Units of the Military Corps of the Italian Red Cross (CRI) are mainly represented by mobile units resulting from a concept and design based on modular system criteria. This design approach subdivides a system into smaller parts called "modules" that can be independently created and then used in different systems.[1] Unit modules can be articulated together and, with more advanced facilities, such as a field hospital.[2] The main question for this topic is *how effective can mobile modular units be in the case of major disasters or Chemical, Biological, Radiological, Nuclear and explosive (CBRNe) events?* They are effective in that they help to separate ordinary health activities from those closely related to the major emergency event. Thus, the scene needs to be isolated to mitigate any consequences. In addition, they are useful for creating high-tech mobile medical and biological laboratory solutions, perfect for both permanent and temporary uses (i.e., short- or long-term uses). They are almost instantaneously ready for operation, easily moveable and can be shipped by air, sea, or by truck. They come in multiple sizes, and are durable in unpredictable weather conditions.[3] Notably, a shipping container that can be adapted and used for a laboratory module would be an example of "science in a box".[3] Mobile laboratory units provide biomedical technicians with the potential ability to perform their work duties and quality protocols in remote areas. The mobile laboratory provides a flexible and affordable working area for equipment and systems that combine the advantages of current and emerging technologies.[4] The challenge is to take these instruments and methods out of fixed site laboratory facilities. To achieve this, tools, materials and methods have to be adapted, compacted and tested in field conditions. The time needed for transporting and deploying the mobile laboratory should be short since the different components can be easily packaged and moved together with a limited staff of trained experts.[3-5]

Different concepts regarding the most suitable characteristics of a mobile capacity should be considered. It is noteworthy that the location of deployment (i.e., areas easily accessible *versus* poorly accessible by road), as well as the duration and frequency of the mission, should determine the most suitable features of the laboratory.[5] Light field capacities could be applied for rapid intervention, including chemical and biological interventions, by using normal tents or easily-built structures.[6] On the other hand, the use of sheltered modules allows the transport and use of biomedical laboratories under extreme conditions.[7] In this regard, an example is seen in the laboratory module of the Military Corps of the Italian Red Cross, which encloses diagnostic emergency tests. Hence, by reporting the main features and analytical capabilities of the sheltered laboratory module, we highlight the critical issues and perspectives of mobile systems in the context of major disasters.

The mobile laboratory of the Military Corps of the Italian Red Cross

Design characteristics

The sheltered laboratory was designed for field use in accordance with Military Design Criteria for Military Systems.[5] The design is based on the concept of being ready-to-use at extreme environmental conditions in accordance with the safety and protection criteria,[5] (Italian company R.I. SpA - Modular Building System, http://www.ricopre.it), (see Fig. 1). It can be used individually although it is generally connected to other modules through pneumatic modular tents. It can be transported on container flat racks in compliance with the International Convention for Safe Containers regulations, by rail and ship, with tactical military vehicles.[7] Its potential activity covers both humanitarian and civilian scenarios. In particular, during a conflict it can be used as a linking-structure between the area of conflict and complex health facilities, while during the post-armed-conflict period it can be implemented as a temporary structure in case of a shortage in local health services. In addition, it can be applied as a structure for maintaining standard hygiene in a field hospital, for environmental control, for sanitary checks on the water supply, for hospital waste management and proper use of disinfectants.[7] For civil specifications, the sheltered laboratory could be used in a variety of anthropic scenarios, including chemical scenarios, linked to technological risks and industrial accidents, and various natural scenarios, in which earthquakes are one of the main risks.[3-5] The module can be located in close

Figure 1. Outside and inside views of the sheltered laboratory of the Military Corps. This module is six meters long (upper panel). The outside view (left-bottom panel) shows details of the pneumatic positioning system. The outside-lateral view shows the entrance and power plugs (right-bottom panel). The inside view shows the position of the equipment.

proximity of the emergency event for monitoring and controlling both the population and the presence of harmful substances in the environment.[3-5] On the other hand, it can intervene in mass health relief that may also involve social events such as sudden population transmigration. In addition, it is useful for the assistance of vulnerable categories from a health point of view including people with cardiopathic and diabetic problems.[3,5,7] In both scenarios, it is used for different activities including control and maintenance of instruments, as well as collection and control of analytical data. Moreover, the mobile laboratory is the result of a military working group made up of biomedical technicians who are ready to participate in activities directed by the *Ispettorato Nazionale* of the Military Corps (Major General Med. CRI Gabriele Lupini, Commander of the Military Corps of CRI), and coordinated by the Health Office (Colonel Med. CRI Romano Tripodi, Chief Health Officer), and by the Office of Operations and Training (Colonel CRI Rocco Cosentino, Chief Officer).

Analytical capabilities: point-of-care testing

New planning perspectives for the laboratory module have to be considered for contrasting technical and logistic criticalities, in particular, during major disasters. In order to achieve analysis results in a short time, point-of-care testing (POCT) is often required with the characteristics of compactness, autonomy, maximum portability and immediate response.[8] With their compact design, these instruments provide portability in the field and can run tests just about anywhere.[9]

POCT can be considered as "health support" in CBRNe scenarios. In particular, some tests are used to identify and confirm the presence of pathogens in a short time.[3] During an emergency, priority is given to laboratory tests for the initial evaluation of the injured subject i.e., by testing arterial gases and pH-blood using hemogasanalysis and with a clinical evaluation of hemorrhage and the extent of possible coagulation dysfunction. Other high priority emergency tests, relate to the cardio-circulatory system, the kidneys as well as pancreatic disorders.[7] An emergency problem of great interest regards the permanent migration flow to Europe, particularly towards the Italian coasts, which requires more health-security measures. The laboratory's analytical capabilities can meet this need with a rapid determination of possible pathogens (i.e., blood or serum biomarkers for malaria, leishmania, chagas, pediatric parasitosis and other endemic diseases), contributing to migrant care and thus preventing the spread of infectious diseases. Four different concepts relate to the analytical capabilities of POCT used in the sheltered laboratory: i) a laboratory in a cartridge, ii) transformation of near-patient testing, iii) critical decision making based on a single testing solution, iv) real-time analysis in a simple, smart module. These concepts have been considered on the basis of the possible activities carried out by the laboratory unit of analysis (Table 1).

POCT instruments useful for CBRNe events are designed according to the concept of "a laboratory in a cartridge". The cartridge has become the symbol of the molecular revolution, making complex technology simple and easy to use. Testing

Table 1. Analytical capabilities of the point-of-care testing.

Capabilities	Concept
1. Complex molecular analysis carried out with simple and compacted tools	A laboratory in a cartridge
2. Optimization of patient care by using near-patient testing	Transforming of near-patient testing
3. Single accurate and dependable testing solution for providing reliable results	Critical decision making based on a single testing solution
4. Automated and modular system for performing real-time results	Real-time analysis in a simple, smart module

processes are handled within the cartridge chambers, from sample preparation and DNA extraction, to amplification and detection, by using advanced microfluidics.[10] The concept of "transforming of near-patient testing" is based on the question: how could a rapid molecular result optimize patient care? POCT instruments enable medical providers to identify and treat diseases early, increasing opportunities to improve patients' survival. POCT could be positioned very close to the patients and it provides reliable monitoring of patients' disease progression. These capabilities have been developed by considering clinicians that often have to make immediate treatment decisions based only on signs and symptoms due to poor access to sensitive, rapid diagnostic tests and long turnaround times for laboratory PCR results.[11] Often, POCT makes critical decisions with a single testing solution. A blood POCT analysis system provides reliable results on which to make critical treatment decisions. Combination of biosensors and calibrators provides high-quality results. They are accurate and dependable, with continuous quality control checks and produce minimal waste. Single-use reagents reduce many of the problems of multi-use systems. A single test can be carried out by inserting 2 or 3 drops of blood into the system.[12] Some of the POCT instruments perform real-time blood chemistry diagnostics for urgent care and emergency responses in a simple and smart module. Reagent discs deliver complete results in real-time by using a very small sample, only 100 microliters of whole blood, serum or plasma. A real-time controller monitors and checks all the measurements. This fully automated system requires no special operating skills. The concept of a modular system is evident in these instruments. They are available in one, two, four, or more-module configurations (all systems can be easily upgraded with additional modules).[13]

Conclusion

In summary, we can assume that the concept of modular systems, for both the laboratory and the instruments, is of paramount importance for developing simple and effective units that can be easily linked together. We can demonstrate that the effectiveness of the mobile system lies in its versatility, by adding operative response capacities in an emergency context, synergically with the main activities of first responders. In conclusion, the sheltered laboratory is an example of the proper use of unit modules to promptly achieve analysis results in the case of a major disaster.

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Conflict of interest

The authors declare no conflict of interest.

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