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Prototype Implementation and Automatic Determination of Pre-Transfusion Tests Based on Image Processing

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INTRODUCTION

Before conducting a blood transfusion is necessary to perform a set of procedures to achieve the compatibility between the blood of the individual, who need to receive blood transfusion, and to select the blood for transfusion (Rod, Tate, & Trent, 2005)(Hoffbrand, Pettit, & Moss, 2004)(Caquet, 2004). The procedures to carry out include (Mitchell, Brain, & I. Bates, 2001)(Roback, Grossman, Harris, & Hillyer, 2011)(Hammering, 2012)(Hillyer, Silberstein, Ness, Anderson, & D., 2007):

1. Determining the A, B, AB, O (ABO) and Rhesus (Rh) factor of the patient;
2. Perform reverse grouping: ABO reverse grouping of the patient;
3. Perform Rh (C, c, E and e) and Kell (K) phenotype for detecting the presence of antigens in the patient's blood. Search of other antigens may also be performed, but in few situations;
4. Perform search for antibodies to detect the presence of significant antibodies. If the search for antibodies is positive, one should perform the identification of antibodies to allow selecting compatible blood;
5. Compare the results with the previous data, if available;
6. Select the red blood cells of the donor and perform the crossmatch.

All these procedures should be performed before administering a blood transfusion in order to ensure maximum compatibility between the donor and the receiver. For performing these procedures some techniques can be used, especially the plate test (Cressiers/Morat, 2008a), the tube test (Cressiers/Morat, 2008a), the microplate test (Hoffbrand et al., 2004) or the gel centrifugation test (Cressiers/Morat, 2008b), Table 1.

Through Table 1 it is possible to observe which plate test and tube test are exclusively performed manually. Although in the tube test it is necessary to include centrifugation in the proceeding. Relatively to the microplate and gel centrifugation tests procedures it is possible to see that both are semiautomatic or automatic. The plate test and the tube test are the ones presenting a simpler and faster procedure, comparatively to other tests presented in Table 1; these are the techniques best suited to emergency scenarios (Cressiers/Morat, 2008a). The microplate and centrifugation gel tests are more time consuming,

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Table 1. Comparison of different tests procedure

Test	Test Principle	Technology	Time (Minutes)	Cost per Test*	Features
Plate	Agglutination	Manual	≈ 2-5	++	Less sensitive, fast
Tube	Agglutination	Manual	≈ 7-10	++	Sensitive, centrifugation necessary, fast, difficult to automate
Microplate	Agglutination	Semiautomatic, automatic	≈ 30	+++	Sensitive, centrifugation is not always required, fast
Gel-centrifugation	Agglutination	Semiautomatic, automatic	≈ 20	+++	Sensitive, centrifugation necessary, slow

Cressiers/Morat, 2008a,b; Hoffbrand et al., 2004.
*From less expensive, +, to most expensive, +++

but are more sensitive than the previous techniques (Hoffbrand et al., 2004) (Cressiers/Morat, 2008b). Furthermore, microplate and centrifugation gel tests, require large, heavy and expensive systems which its execution is at the laboratory level and not allowing the performance of these tests elsewhere. This arises the time for obtaining results in these cases, not only in performing the test procedure, but also considering the delay associated with the laboratory movements required.

Thus, in emergency situations where time available is few, we resort to blood type O negative (the universal donor) as it offers a lower risk of incompatibilities (Rod et al., 2005)(Hoffbrand et al., 2004) (Caquet, 2004). However, despite the lower risk of incompatibilities, it continues to exist and given that transfusion reactions can lead to death of the individual is essential to avoid them (Rod et al., 2005) (Hoffbrand et al., 2004)(Caquet, 2004). In addition to using the universal donor, human error in the testing procedure, in the reading and interpretation of results are also factors that increase the risk of incompatibilities and can even be fatal for individuals (Myhre & McRuer, 2000)(Delamaire, 2005)(Brown & Crim, 2007)(Petaja, Andersson, & Syrjala, 2004)(Henneman et al., 2007)(Wagar, Tamashiro, Yasin, Hilborne, & Bruckner, 2006)(Turner, Casbard, & Murphy, 2003)(Callum et al., 2001)(Mueller & Seifried, 2006) (Stainsby et al., 2006). Thus, human error is one of the most significant causes of fatal blood transfusion and is extremely important to automate the testing including reading and interpreting of the results (Myhre & McRuer, 2000)(Delamaire, 2005)(Brown & Crim, 2007)(Petaja et al., 2004)(Henneman et al., 2007)(Wagar et al., 2006)(Turner et al., 2003)(Callum et al., 2001)(Mueller & Seifried, 2006)(Stainsby et al., 2006). Moreover, the existence of exchange between the blood that is sent from the laboratory to the transfusion receiver and the blood transfused to the receiver can also result in incompatible blood transfusions. During the path between the laboratory and the location where the receiver of the blood transfusion is, it may occur exchange of blood units that were prepared and intended for other individuals. These exchanges may generate incompatible blood transfusions.

Thus, this work aims to develop a system able to determine the blood type of an individual, in a short period of time, adapted to urgent situations. Being a portable prototype, it can be easily used in different hospital services, allowing confirmation of blood to be transfused. Thus, making it a quick test to the patient, it easily confirms that the blood sent is suitable for this patient, avoiding incompatibilities that a possible exchange could cause. To this end, it is proposed the construction of a prototype based on the plate test, which gives fast results. Moreover, it is intended that the prototype be of reduced dimensions so that it can easily be used at other locations beyond the laboratory. Furthermore, this prototype should be able of performing automatically mixing, reading and interpreting of the results, eliminating the possible human errors occurring in the test procedure and in the interpretation of results.