



# Emergency preparedness for mass casualty events: South Texas commentary on the development of a statewide emergency response system

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## SUMMARY

Mass casualty incidents (MCIs) are on the rise in the USA, and hemorrhage is the leading cause of preventable death in trauma. The need for rapid access to life-saving blood and blood products is essential for preventing death due to hemorrhage. It is well established that most major cities in the USA are underprepared to meet blood transfusion requirements in the event of an MCI. The South Texas Whole Blood Consortium sought to rectify this and vowed to be prepared to provide low-titer type O-positive whole blood (LTOWB) and blood components to the people who need it, where and when they need it. This system was able to transport 25 units of LTOWB and packed red blood cells almost 100 miles away to Uvalde Memorial Hospital within just 67 minutes after notification of an active shooter. The regional consortium has created a pool of dedicated LTOWB donors affectionately called Heroes in Arms who can be called on to instantly augment locoregional blood supply. Previously pregnant women have historically been excluded from donating plasma and LTOWB due to the increased rates of human leukocyte antigen (HLA) antibody (Ab) positivity, which is associated with transfusion-related acute lung injury. However, the South Texas Blood and Tissue Center in San Antonio had a large number of qualified, previously pregnant females desire to join the Heroes in Arms program prompting them to assess the feasibility of providing HLA Ab testing for this demographic and the results were promising. This is the first report of previously pregnant women being included in the pool for donation of LTOWB.

## BACKGROUND

Despite advances in trauma and critical care, hemorrhage remains the leading cause of preventable death in trauma patients.<sup>1,2</sup> Rapid transfusion of blood and blood products along with hemorrhage control have been shown in multiple studies to be key in improving mortality.<sup>3–5</sup> A mass casualty incident (MCI) is defined as an event that overwhelms emergency medical response systems and results in a rapid depletion of available blood and blood products.<sup>1</sup> MCIs are high-profile contributors to the number of annual trauma-related deaths in the USA. Studies have shown that hemorrhage control and sufficient blood supply are fundamental

to improve mortality outcomes.<sup>6</sup> From the work by Cannon *et al*,<sup>7</sup> a simulated blast event creating an MCI scenario revealed insight into the shortage of blood supply in major cities all over the USA. This prompted deliberations on how to bridge the supply and demand gap while optimizing resuscitation. The state of Texas spans 268 597 square miles (mi<sup>2</sup>) and contains 191 rural counties. Rural MCIs tend to have greater numbers of victims, which further supports widespread, rapid access to life-saving blood and blood components.<sup>8</sup> Survival is optimized by initiating transfusion as early as possible to prevent death from hemorrhage.

## South Texas whole blood consortium

Texas has developed a unique program called the Texas Emergency Medical Task Force (EMTF) with a focus on acute medical care, including transport, hospital surge staffing and mobile medical units that can be deployed during an MCI.<sup>9</sup> It is divided into eight regional advisory committee geographic regions. After the Sutherland Springs shooting that resulted in 26 fatalities and several more wounded at a church service in November 2017, the Southwest Texas Regional Advisory Council (STRAC), South Texas Blood and Tissue Center (STBTC), University Health System, the University of Texas Health Science Center at San Antonio and the San Antonio Fire Department formed a consortium to implement the nation's first multidisciplinary, multi-institutional, regional low-titer type O-positive whole blood (LTOWB) program. Low titer is defined as IgM anti-A and anti-B antibody (Ab) titers <256. This program established a process to provide LTOWB for prehospital transfusion for hemorrhagic shock to the area of the trauma system encompassing 22 counties and 26 000 mi<sup>2</sup>, with a population of approximately 2.5 million.<sup>9</sup> In addition, a strategy to rapidly deploy LTOWB to the site an MCI anywhere in Texas has been developed. This intervention provides the potential for life-saving prehospital resuscitation at a critical juncture, prior to patient arrival at a designated trauma center.<sup>10</sup>

## MCI response in action

The first time the MCI LTOWB deployment was utilized occurred on May 24, 2022 in Uvalde, Texas,

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during the event of an active shooter incident at an elementary school. When the EMTF State Coordination Office received the call about the mass shooting, the MCI Whole Blood Protocol was activated and consisted of the STBTC preparing 15 units of LTOWB and 10 units of leukoreduced O-negative packed red blood cells (LPC). Concurrently, an air medical helicopter was dispatched to transport the blood from STBTC. From notification to arrival at Uvalde Memorial Hospital, a regional level IV trauma center receiving MCI casualties, it took only 67 minutes to transport the blood. Additional 20 units of blood products were available at Uvalde Memorial Hospital from medical facilities and emergency medical service (EMS) agencies in neighboring counties and regional collaborators as a part of the call to action. In total, there were an additional 45 units of blood products available within 90 minutes to augment the local hospital supply, which does not keep plasma in stock.<sup>11</sup> This operation support plan serves as an excellent example of what is possible within our current infrastructure. After the MCI in Uvalde, all unused whole blood (WB) and blood products were circulated back throughout the system so that it was not wasted and did not overextend the main supply.

### From brothers to heroes in arms

'Brothers in Arms' was a blood program conceived and implemented by the San Antonio Blood Consortium to generate a donor pool of LTOWB male donors throughout the city who donate blood at regular intervals. Donors in this group are part of a dedicated donor program distinct from the regular donor pool. STBTC has screened over 10 100 men for the program and the results of their anti-A and anti-B Ab testing revealed that 82% of potential male donors qualify as low titer and are allowed to enroll in the program. As of March 2023, 4411 volunteers have donated at least once in the last 12 months and 2539 have donated multiple times. With the success of the program and the rising incidence of MCIs throughout the state, the consortium shifted its focus to increase the donor pool for future MCIs. The first major step was to assess the feasibility and safety of adding women to the program as STBTC already had a large number of female donors come forward expressing interest in joining the 'Brothers in Arms' program. Automatically excluding women from the donor pool results in a 50% reduction of potential donors. There is some concern currently surrounding the use of LTOWB from female donors, particularly women with a previous history of pregnancy, due to the association of human leukocyte antigen (HLA) Abs and transfusion-associated acute lung injury (TRALI). In 2014, the Association for the Advancement of Blood and Biotherapies (AABB) came out with a risk reduction strategy to reduce the risk of TRALI, which is a potentially lethal side effect of transfusion. They discovered that the highest incidence of TRALI occurred from female plasma donors with a history of pregnancy and associated HLA Ab positivity.<sup>12</sup> However, studies have shown that women who have never been pregnant carry the same risk of HLA positivity as men.<sup>13</sup> The AABB Bulletin advocates that women who are donating plasma need to be screened by either a pregnancy questionnaire or an HLA Ab testing.<sup>12</sup> STBTC has since begun asking all female donors about a history of live birth at every donation. Donors who answer 'yes' to a history of live birth are tested for HLA antibodies. Donors who test positive for HLA antibodies are deferred from donating WB, plasma and apheresis platelets. Aside from the concern for HLA positivity, the theory was that women have higher anti-A and anti-B antibody levels. However, since adopting women into the program, STBTC

has screened 352 women and 69% were considered low titer. The current goal is to screen 2000 women in the coming year to qualify for LTOWB donation. The hemoglobin cut-off for women in the program is 12.5 g/dL, which occasionally results in donation deferral among women who are menstruating or have chronic anemia which will affect the number of female donors STBTC will need to identify for donation. As of January 2023, O-positive, previously pregnant, HLA negative or never pregnant women qualify for the now-aptly-named 'Heroes in Arms'.

Potential donors are required to meet many qualifications to participate in the Heroes in Arms program. Once included in the program, Heroes in Arms donors are associated with an 89% appointment show rate, which is significantly higher when compared with platelet donors at 82% and non-LTOWB donors at 61%. The San Antonio area Heroes in Arms donors have proven to be well committed to the program and frequently answer the call when asked.

The current collection goal is 25 donations from Heroes in Arms contributors per day to always keep an inventory of 100 units available at STBTC. There are more donors being screened than enrolled in the program as evidenced by the large pool of eligible men who have never donated and that number will only increase with the addition of potential female donors. STBTC is currently limiting screening at fixed sites to a maximum of nine per day (four men and five women), which covers donors who discontinue or lapse out of the program in an effort to control for the cost associated with screening while simultaneously keeping the donor pool large enough to stock the shelves. The donor is ABO re-typed at every donation, but titer testing is only performed once per year after initial screening. STBTC screened 2151 previously pregnant women in 2022 for HLA Ab testing and 1789 (83%) tested negative while only 362 (17%) tested positive. Assuming the same low-titer screen results as non-pregnant women, 57% of previously pregnant women would be eligible for Heroes in Arms regardless of which screening test was done first.

### Barriers and strategies in implementation

One of the biggest keys in the success of this program was gaining buy-in from all parties. It is truly a multidisciplinary effort from San Antonio's Whole Blood Consortium. This is comprised of ground and helicopter EMSs, fire department, the STBTC, two level one trauma centers in the city area and all the surrounding affiliated trauma centers within the south Texas area that is overseen by STRAC.

The infrastructure within STRAC has allowed us to monitor product rotation for optimal use, with adequate storage of the LTOWB units while being transported with EMS and the ability to track and report clinical outcomes of the program. The coordinated effort and trust between all parties have been fundamental in optimizing the rotation of blood in such a way that the waste has become less than 1%. For the first 2 weeks, the units of LTOWB are being transported by EMS around the region to be available for prehospital transfusion; once the unit reaches day 15 of life, it gets transferred to our academic level one trauma center for the remaining lifespan to be used for in-hospital transfusions. The willingness to take the older LTOWB after it has been rotated from the prehospital setting is critical to expanding the program while ensuring good stewardship. During the last 5 years, the use of LTOWB at University Hospital has expanded at the hospital. As University Hospital increases the amount of LTOWB units they can have on hand while carefully balancing expirations, more prehospital groups have joined the program.

Regarding challenges to implementation, determining the appropriate number of donors needed to be screened daily and from that to maintain adequate supply has been the biggest hurdle. Publicity and incentive strategies have been key to engage the population, promote blood donation and continue engagement. Another critical aspect is ensuring ongoing engagement with all program partners. Regular monthly meetings that include representatives from each party has been helpful for a continuous development of the program, as well as other aspects like our mass casualty activation program.

## CONCLUSION

This article focused on the examination of emergency preparedness for mass casualty events. A significant aspect of MCI care is the ability to provide blood and blood components in sufficient types and quantities to prevent deaths due to hemorrhage. The supply shortage throughout the USA has been revealed through simulations, which has led to development of options to bridge the supply and demand in major cities.<sup>3</sup> Texas has implemented the nation's first multidisciplinary, multi-institutional, regional LTOWB program with a focus on rapidly deploying WB to the site of an MCI throughout the South Texas region. The effectiveness of this program was seen in the Uvalde, Texas, active shooter incident. In just over an hour, dozens of units of LTOWB and LPC were transported almost 100 miles away with additional units of blood products available at Uvalde Memorial Hospital to augment local supply. It is important to note that the WB used for these incidents does not take away from the normal donor pool and is kept in a production rotation for optimal use of all WB to minimize waste. Instead, the supply comes from programs such as Heroes in Arms which now includes both male and female prescreened LTOWB donors. To the authors' knowledge, this is the first report of including women with a history of pregnancy in an LTOWB donor program for early resuscitation in hemorrhagic shock.

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## REFERENCES

- 1 Braverman MA, Smith A, Shahan CP, Axtman B, Epley E, Hitchman S, Waltman E, Winckler C, Nicholson SE, Eastridge BJ, *et al*. From battlefield to hometown: creation of a civilian walking blood bank. *Transfusion* 2020;60 Suppl 3:S167–72.
- 2 Cantle PM, Cotton BA. Prediction of massive transfusion in trauma. *Crit Care Clin* 2017;33:71–84.
- 3 Spinella PC, Cap AP. Prehospital hemostatic resuscitation to achieve zero preventable deaths after traumatic injury. *Curr Opin Hematol* 2017;24:529–35.
- 4 Holcomb JB. Optimal use of blood products in severely injured trauma patients. *Hematology Am Soc Hematol Educ Program* 2010;2010:465–9.
- 5 Shackelford SA, Del Junco DJ, Powell-Dunford N, Mazuchowski EL, Howard JT, Kotwal RS, Gurney J, Butler FK, Gross K, Stockinger ZT. Association of Prehospital blood product transfusion during medical evacuation of combat casualties in Afghanistan with acute and 30-day survival. *JAMA* 2017;318:1581–91.
- 6 Stubbs JR, Jenkins DH. Blood transfusion preparedness for mass casualty incidents: are we truly ready. *Am J Disaster Med* 2019;14:201–18.
- 7 Cannon JW, Igra NM, Borge PD, Cap AP, Devine D, Doughty H, Geng Z, Guzman JF, Ness PM, Jenkins DH, *et al*. U.S. cities will not meet blood product resuscitation standards during major mass casualty incidents: results of a THOR-AABB working party prospective analysis. *Transfusion* 2022;62 Suppl 1:S12–21.
- 8 University N. Mass killing database: revealing trends, details and anguish of every US event since 2006. USA today. 2023. Available: <https://www.usatoday.com/in-depth/graphics/2022/08/18/mass-killings-database-us-events-since-2006/9705311002/> [Accessed 28 Feb 2023].
- 9 Epley E. STRAC EMTF-8. STRAC. 2023. Available: <https://www.strac.org/emtf8>
- 10 Pokorny DM, Braverman MA, Edmundson PM, Bittenbinder DM, Zhu CS, Winckler CJ, Schaefer R, McGinity AC, Epley E, Eastridge BJ, *et al*. The use of prehospital blood products in the resuscitation of trauma patients: a review of prehospital transfusion practices and a description of our regional whole blood program in San Antonio, TX. *ISBT Science Series* 2019;14:332–42.
- 11 Ciaraglia A, Brigmon E, Braverman M, Kidd E, Winckler CJ, Epley E, Flores J, Barry J, DeLeon D, Waltman E, *et al*. Use of whole blood deployment programs for mass casualty incidents: South Texas experience in regional response and preparedness. *J Trauma Acute Care Surg* 2022;93:e182–4.
- 12 Association bulletin #14-02. TRALI risk mitigation for plasma and whole blood for allogenic transfusion. Bethesda, MD AABB; 2014. Available: <https://www.aabb.org/docs/default-source/default-document-library/resources/association-bulletins/ab14-02.pdf>
- 13 Triulzi DJ, Kleinman S, Kakaiya RM, Busch MP, Norris PJ, Steele WR, Glynn SA, Hillyer CD, Carey P, Gottschall JL, *et al*. The effect of previous pregnancy and transfusion on HLA alloimmunization in blood donors: implications for a transfusion-related acute lung injury risk reduction strategy. *Transfusion* 2009;49:1825–35.