

Preparing for Rare Medical Events: A Case Study in Resuscitative Hysterotomy

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SUMMARY

In healthcare, there are situations that clinicians seldom face, yet have to be prepared for. One such example is a resuscitative hysterotomy. This paper presents how, through the use of hierarchical task analysis and consideration of work systems elements, a basis can be constructed for future work in developing both training and wider work system considerations for this type of procedure. Review of the latest guidelines and a total of 26 observations of demonstrations by faculty and attendees practicing a resuscitative hysterotomy during a new training package were used to explore the wider task context, identify the sub-operations for the procedure of a resuscitative hysterotomy, and document potential system considerations. From the task decomposition, key work system considerations already became visible. These included the SEIPS components of person(s), organisation of work, tools and technology and internal environment. For this procedure, there are multiple task and work system considerations for performing this procedure that add to the complexity of how to prepare clinicians for this. Using the task decomposition diagrams and tables, an in situ simulation could be developed that helps the organisation not only train staff but also evaluates the organisation's preparedness for such events. The work system considerations identified provide an initial basis for this type of evaluation.

KEYWORDS

Healthcare, Hierarchical Task Analysis, Systems Analysis

Introduction

In healthcare, there are situations that clinicians seldom face, yet have to be prepared for. Ideally, skills are developed through real-life clinical exposure, supported by educational materials such as guidelines and formal training. In some cases, there is no opportunity to practice and develop these skills in situ, as the clinical need rarely presents itself. In these cases, different forms of simulation can be beneficial.

One such example is the need to restore spontaneous circulation in pregnant women in cardiac arrest through a resuscitative hysterotomy. This type of procedure is incredibly rare but performing it can greatly improve clinical outcomes for the mother (Beckett et al., 2017; Leech, Nutbeam, et al., 2025). This medical intervention should be performed as soon as possible, at the site of cardiac arrest by a skilled team (Lott et al., 2025). It is not unusual for a clinician to go through their career without ever having witnessed this procedure before they are required to perform it. Furthermore, due to the time sensitivity, an attending doctor may need to perform this procedure before more specialised teams can arrive. This raises the question of how best to prepare clinicians to undertake this rare procedure. Taking this one step further, how do we prepare our healthcare systems to support clinicians in performing these procedures? A recent study highlighted existing gaps in

preparedness to manage emergencies in this patient group across Europe (Krawczyk et al., 2024), indicating that organisational readiness needs to be considered in tandem with clinician training.

To address the gaps in training for clinicians and highlight some of the most recent changes described in the European Resuscitation Council Guidelines 2025 for Special Circumstances in Resuscitation (Lott et al., 2025), a new training package on maternal cardiac resuscitation and emergency skills training (M-CREST) in the ICU environment for registrars (senior residents) in intensive care medicine was developed. This skills training package was held for the first time on 07/11/2025 at Nottingham University Hospitals (NUH) NHS Trust for registrars in intensive care medicine working in the East Midlands.

To support the further development of this training package and to inform in-situ simulation used to assess organisational preparedness, this initial training day was analysed using Hierarchical Task Analysis (HTA). The benefit of this approach is that the HTA method allows for the proceduralizing of complex tasks that occur infrequently in healthcare and can support the development of simulation-based education (O'Connor & O'Dea, 2025). Additionally, through the use of a systems model to structure the analysis, elements that could be used to evaluate organisational preparedness were identified.

Method

Initially a HTA (Shepherd, 1998) was generated for the broader activities associated with maternal cardiac arrest by reviewing the European Resuscitation Council Guidelines 2025 (Lott et al., 2025). The purpose of this high-level analysis was to position the resuscitative hysterotomy procedure, which is the focus of this paper, within the wider range of activities necessary for treating maternal cardiac arrest. Following this, a specific HTA for the resuscitative hysterotomy procedure was generated through observation of the new M-CREST training package on this topic.

Information for the HTA was collected by three members of NUH's Human Factors team, of which one member was a chartered Human Factors Specialist. As the training package consisted of three components, namely a practical resuscitative hysterotomy station, a practical station on basic neonatal life support and a station set up with two scenarios to explore crew resource management elements, a member of the team observed each station before rotating with the group to the next station. Each Human Factors Team member was able to observe each training component. For the resuscitative hysterotomy station, the procedure was demonstrated and practised on porcine models. A total of 26 observations of the demonstrations by faculty and attendees practicing the procedure (under guidance from the faculty) were viewed by the Human Factors team. The team noted each of the steps described through the demonstrations by faculty, and then noted the steps and actions completed by the attendees practicing the procedure. Additional comments made by faculty during the demonstration and in response to questions raised by attendees were documented.

The framework for conducting an HTA described by Stanton (2006) was used to guide the analysis. For both the higher level task of restoring spontaneous circulation in pregnant patients and for the procedure of a resuscitative hysterotomy, hierarchical diagrams were generated and the results were also compiled in the tabular format. The benefit of using both formats is that the diagram allowed better visualisation of task and the tabular format allowed for the documentation of more detail for each sub-operation (Stanton, 2006).

The generated HTA was then reviewed by S. Cantellow, who contributed to the relevant ERC guidance addressing the conditions required for successful resuscitative hysterotomy as well as a consultant obstetrician and a consultant in pre-hospital medicine who has performed this procedure. In addition to this, during the observation of the training day, potential work system considerations brought up through discussion were documented and mapped to the Systems Engineering Initiative

for Patient Safety (SEIPS) 2.0 model (Holden et al., 2013). The mapping to the SEIPS framework was conducted by one of the authors (EC) and reviewed by the co-authors. The identified work system considerations were supplemented by including work system considerations mentioned in key pieces of literature (i.e. Leech, Main, et al., 2025; Leech, Nutbeam, et al., 2025; Lott et al., 2025).

Results

The purpose of the HTA was to analyse the procedure of a resuscitative hysterotomy by exploring the wider task context, identifying the sub-operations, and documenting the potential system considerations. This will be used to support the further development of training packages and provide guidance on determining organisational readiness. The system boundary for this analysis was limited to the tasks associated with the primary components of maternal cardiac resuscitation and the data was limited to the role and perspective of specific specialist consultant clinicians that formed the faculty for the training day and registrars attending the training package, which was set within an ICU context.

Maternal cardiac arrest refers to cardiac arrest that occurs at any stage in pregnancy or within six weeks after birth (Lott et al., 2025). When cardiac arrest occurs, the primary goal of clinicians is to restore spontaneous circulation. Due to the physical and physiological changes that occur in pregnant patients, additional guidelines have been written to describe the modifications needed for basic and advanced life support for the prevention and treatment of cardiac arrest (Lott et al., 2025). These guidelines were used to generate the first hierarchical diagram, depicted in Figure 1, describing the high level tasks involved in restoring spontaneous circulation in pregnant patients.

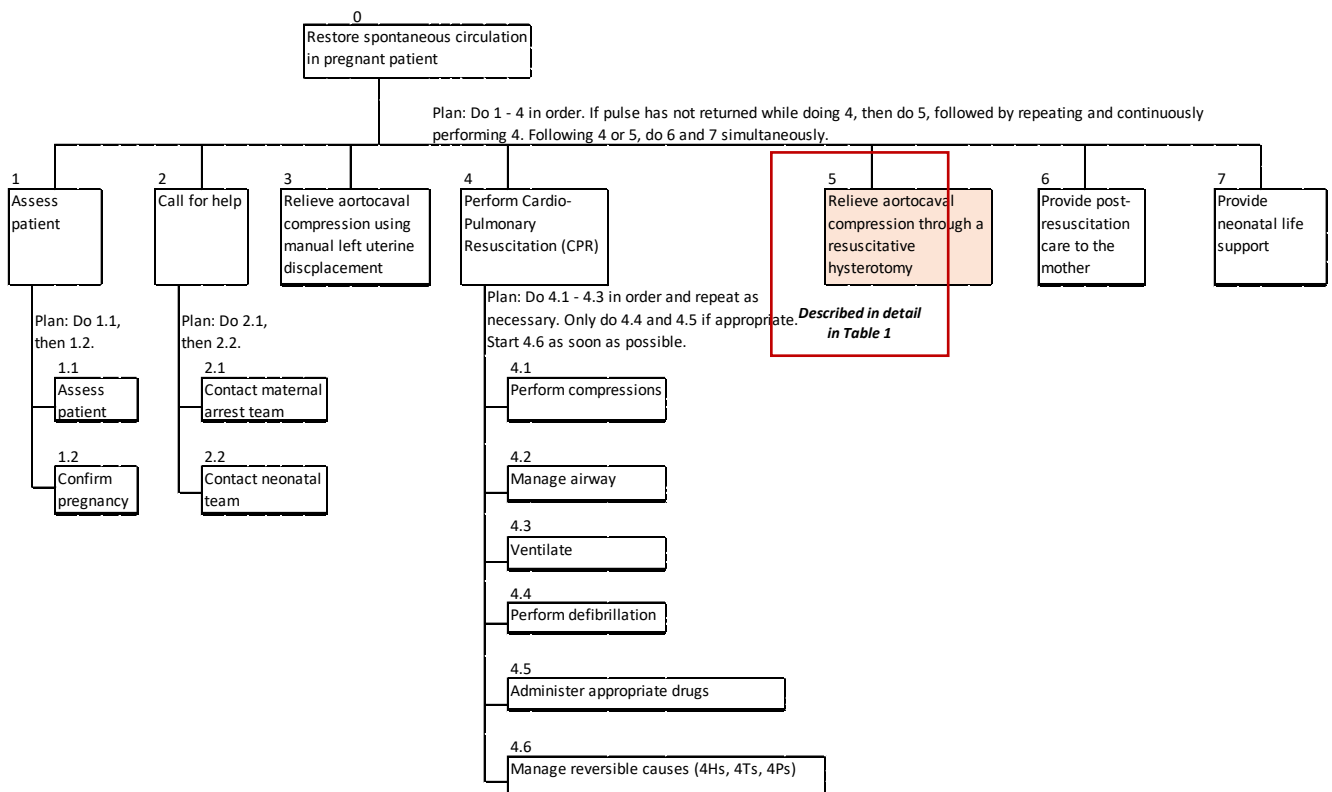


Figure 1: The hierarchical diagram for the goal of restoring spontaneous circulation in pregnant patients.

The purpose of this depiction is to position the resuscitative hysterotomy procedure, which is the focus of this paper, within the wider range of activities necessary for treating maternal cardiac arrest. As a result of this, the additional activities involved in treating maternal cardiac arrest have only been described at a high level and only include limited detail associated with the sub-goals and operations. For example, for sub-goal 4 (performing CPR), specific algorithms have been developed by the medical community for this sub-goal that contain greater detail of the operations that need to be completed. In this paper, this sub-goal has only been superficially described as to reference how these task elements may interact with performing a resuscitative hysterotomy (sub-goal 5). A resuscitative hysterotomy is undertaken in pregnant patients when relief of the aortocaval compression using manual left uterine displacement has not been effective (sub-goal 3) and cardio pulmonary resuscitation has not allowed for the return of spontaneous circulation (sub-goal 4). This is described in the plan of the HTA in Figure 1. The diagram also highlights how multiple tasks need to occur concurrently, which requires the involvement of multiple specialist teams.

From Figure 1, the goal to relieve aortocaval compression through a resuscitative hysterotomy (sub-goal 5) has been expanded on and analysed in more detail in a second HTA, and is included in Table 1. The task description for a resuscitative hysterotomy is the rapid emptying of the uterus to relieve aortocaval compression so cardiopulmonary resuscitation (CPR) may be effective and allow for return of spontaneous circulation in the mother (Leech, Main, et al., 2025). The HTA generated using the notes from the observation of the training day, broke down this procedure into 5 sub-goals, with a further 20 sub-operations, which according to literature takes approximately 1 minute to complete (Leech, Nutbeam, et al., 2025).

Table 1: Tabular description of sub-goal 5 (performing a resuscitative hysterotomy) from the hierarchical diagram from Figure 1 for the goal of restoring spontaneous circulation in pregnant patients.

HTA No.	Goals and Sub-operations	Notes and Plans
5	Perform a resuscitative hysterotomy	To be performed in pregnant woman > 20 weeks <i>Plan: Do 5.1 to 5.5 in order.</i>
5.1	Prepare for procedure	<i>Plan: Do 5.1.1 to 5.1.5 in order.</i>
5.1.1	Confirm pregnant >20 weeks	May be influenced by what family says and available information (SEIPS – Person, Tools & Technology).
5.1.2	Prepare team	Gather and brief local team that is to undertake procedure. Identify an assistant if available. Ensure other specialist teams have been called for (SEIPS – Organisation). Location will affect this (SEIPS - Internal environment).
5.1.3	Locate the necessary equipment	Influenced by the available equipment in the department (SEIPS – Tools & Technology, Internal Environment).
5.1.4	Remove manual uterine displacement	Relates to Figure 1, sub-goal 3.
5.1.5	Consider pausing CPR	Relates to Figure 1, sub-goal 4.
5.2	Cut through the abdomen	<i>Plan: Do 5.2.1 to 5.2.4 in order.</i>
5.2.1	Prepare skin	
5.2.2	Identify anatomical landmarks	Palpate for orientation.
5.2.3	Identify incision point	
5.2.4	Make vertical sub-umbilical midline incision	Cut through abdominal layers – skin, muscle, fascia until visualising the uterus.
5.3	Open uterus	<i>Plan: Do 5.3.1 to 5.3.3 in order. Do 5.3.4 while completing tasks 5.3.1, 5.3.2 and 5.3.3.</i>
5.3.1	Retract skin to expose uterus	

5.3.2	Make vertical incision into the uterus	Enter uterus with scalpel until the amniotic sac can be seen, or there is expulsion of amniotic fluid.
5.3.3	Extend incision as needed	Use scissors as this provides better control to avoid cutting the baby (SEIPS – Tools & Technology). Cut through placenta if in the way.
5.3.4	Protect baby	While making the incision, protect the baby.
5.4	Deliver baby	<i>Plan: Do 5.4.1 to 5.4.4 in order.</i>
5.4.1	Locate baby	Using one hand, place inside of the uterine cavity and identify baby's head.
5.4.2	Remove baby from uterus	Avoid grabbing at limbs. Ask assistant for a fundal push as pressure might be needed. (SEIPS – Organisation)
5.4.3	Clamp and cut umbilical cord	Leave enough cord to allow for vascular access.
5.4.4	Handover baby to second local team	This would lead to goal 7 in Figure 1. (SEIPS – Organisation). Initial resuscitation of the baby is undertaken by a second local team, and continued by an expert team when the neonatal emergency team arrives.
5.5	Treat mother	<i>Plan: Do 5.5.1 to 5.5.3 in order.</i>
5.5.1	Deliver placenta	Single attempt to deliver placenta with a hand sweep.
5.5.2	Pack wound with swabs	
5.5.3	Carry on resuscitation	This would be re-initiation of goal 4 in Figure 1.

From the task decomposition presented in Table 1, key work system considerations already become visible. These include the SEIPS components of person(s), organisation of work, tools and technology and internal environment. As this intervention is time-sensitive and preparation to perform the procedure should be undertaken early, guidelines recommend the procedure be performed as soon as possible at the site of cardiac arrest by a skilled team. The internal environment component (i.e. the arrest location) may influence team assembly (HTA number 5.1.2), as the initial responders may need to begin the procedure before obstetric and neonatal teams arrive. This may also influence neonatal handover (HTA number 5.4.4) if neonatal staff are not yet present at the point of delivery. Another important interaction between some of these elements is that, while the procedure requires minimal equipment, clinicians still need to locate it quickly in any environment and the availability of the necessary equipment (HTA number 5.1.3) will depend on the availability of the equipment at the location of the cardiac arrest.

Described in Table 2 are additional work system considerations that are unique to this patient group, procedure and may affect the tasks aimed at achieving spontaneous return of circulation described in the above HTAs. For example, aortocaval compression, which is the compression of the inferior vena cava and the aorta by the gravid uterus, usually manifests by the 20th week of pregnancy. This may result in a considerable reduction in venous return and subsequently cardiac output when in a supine position. This is a unique element of this patient group that will limit the effectiveness of CPR, when compared to normal adults (SEIPS – Person) and has resulted in specialist guidelines describing alterations to the adult life support tasks (SEIPS – Task, External Environment). An example of a key organisation element is that as a variety of roles and skills is needed to come together to complete these tasks, this will require all the appropriate specialties to be involved and the quick formation of a group of specialised teams with each having different points of focus. For example, one team will provide post-resuscitative care to the mother (HTA sub-goal 6) and another will be responsible for neonatal life support to the baby (HTA sub-goal 7) (SEIPS – Organisation).

Table 2: Work system considerations for activities associated with maternal cardiac arrest, including specific considerations for the resuscitative hysterotomy procedure.

People	<ul style="list-style-type: none"> • Pregnancy may not always be visible and therefore should be considered in any collapsed woman of childbearing age. • Considering pregnancy is essential for identifying reversible causes (HTA sub-goal 4.6) • Due to anatomical and physiological differences, the steps for advanced life support will need to be modified (HTA sub-goals 2 - 7).
Tasks	<ul style="list-style-type: none"> • Relief of aortocaval compression needs to be maintained throughout resuscitation. (HTA sub-goal 3 and 5). • Acronyms to support clinician actions have been developed (e.g. ABCDE approach for resuscitation, and 4Hs, 4Ts and 4Ps for addressing potential causes for cardiac arrest). • Resuscitative hysterotomy is a time-sensitive task but should not be considered futile beyond 5 minutes. The decision whether to undertake this procedure is often the most challenging aspect of the case (HTA sub-goal 5).
Tools and Technology	<ul style="list-style-type: none"> • Obstetric-specific early warning systems may enable early recognition of deteriorating pregnant patients (HTA sub-goal 1). • 2025 guidelines propose the following prepared equipment: Sterile gloves (non-latex)-gowns-masks, skin preparation solution, 3 scalpels (1: incision, 2: umbilical cord, 3: backup), dissection scissors, laparotomy sponges, 4 haemostat clamps, retractor, gauze (ideally haemostatic), 3 cord clamps, baby hat, 4 towels, heated incubator, and equipment to resuscitate the neonate
Organisation	<ul style="list-style-type: none"> • A multidisciplinary approach is essential and will require the involvement of obstetrics, anaesthesia, critical care and neonatology (HTA sub-goal 2). • Resuscitative hysterotomy requires designated teams and roles, rapid system activation, and equipment readiness (HTA sub-goal 5.1).
Internal Environment	<ul style="list-style-type: none"> • A cardiac arrest in pregnant and peripartum women can occur anywhere and, as the guidelines state a resuscitative hysterotomy should be conducted at the site of cardiac arrest, medical services need to be prepared. • The location of specialist services may affect response time.
External Environment	<ul style="list-style-type: none"> • Given the low frequency of CPR on pregnant women, recommendations are based on observational data and expert opinion rather than randomised trials. • 2025 Guidelines introduces a new process for management of maternal cardiac arrest along with key figures and tables to support clinical application. • The new guideline also de-emphasises the fixed timing for resuscitative hysterotomy, which previously focused on starting the procedure at minute 4 and completing uterine evacuation by minute 5.

Discussion

For the resuscitative hysterotomy, there are multiple task and work system considerations of performing this procedure that add to the complexity of how to prepare clinicians for this. This procedure will be performed in a high stress and time-sensitive context, with the procedure carrying considerable risk, both if performed and if not performed. Clinicians will require both sufficient confidence and skill to decide and perform this procedure, where most clinicians will not have witnessed this procedure prior to having to perform it (Leech et al., 2024). Furthermore, in clinical practice there is uncertainty at what point a resuscitative hysterotomy would be considered futile and as a result recent guidelines do not suggest a “cut off” time for this procedure. Cases have been documented that even after extended periods of maternal resuscitation, a resuscitative hysterotomy may be beneficial (Leech, Nutbeam, et al., 2025). It is unsurprising with all the uncertainty, time-

sensitivity in which a clinician will need to decide and perform this procedure as well as the nature of this task, that it carries a considerable emotional burden (Leech, Nutbeam, et al., 2025). Understanding how staff manage cardiac arrests in a pregnant patient using a work systems perspective is particularly beneficial as this procedure is both logistically and emotionally challenging (Leech, Main, et al., 2025). In light of this, the work system needs to be designed to support clinicians to make this decision and perform this procedure, as well as ensuring support following this procedure, and as described by the multiple influencing work system factors it needs to extend beyond training (Leech, Main, et al., 2025).

Despite the low frequency of CPR on pregnant women, it is still essential to better understand how to improve clinician's responses to maternal cardiac arrest as recent surveillance data (UK Obstetric Surveillance system) has identified a survival rate of 58% with poor outcomes associated with delays in resuscitative hysterotomy (Beckett et al., 2017). Barriers to preparation for cardiac arrest in pregnancy have been identified as including problems with equipment availability and interdisciplinary teamwork (Krawczyk et al., 2024). The work system considerations and task analysis compiled in this paper help expand on how these barriers may affect specific elements of these tasks. The most recent recommendations from guidelines suggest ensuring plans and the necessary equipment are in place considering both the mother and newborn, early involvement of specialist teams such as obstetric and neonatal teams, regular multidisciplinary training for these scenarios and establishing an approach to support learning and team performance (Lott et al., 2025). Considering the complexity that is added by the patient characteristics, internal environment and the need for multidisciplinary teams, to develop and implement these suggested recommendations, a human factors approach with its focus on a systems perspective is well placed to support clinicians with this.

As a significant proportion of maternal cardiac arrests occur outside maternity units and can occur anywhere, it is unsurprising that gaps in preparedness, including multidisciplinary coordination and equipment availability are common and are key barriers to life support in these types of patients (Lott et al., 2025). Using the task decomposition diagrams and tables for these tasks, an in situ simulation could be developed that helps the organisation not only train staff but also evaluate the organisation's preparedness for such events. The HTAs could be used to develop the simulation scenarios for these types of procedures together with clinicians. Additionally by simulating these types of activities in situ, the organisation could also assess a variety of work system considerations, for example:

- Staff awareness of the procedure and available guidelines
- Identify training gaps for staff and teams
- Assignment of team roles and responsibilities
- Evaluation of team dynamics and the ability to form new teams rapidly
- Evaluation of communication channels to ensure the correct teams and staff are reached
- Access and availability of the necessary equipment
- Identify response times and barriers to specialty teams arriving as soon as possible
- Identify any site or location-specific barriers

By assessing these types of work system specific elements, healthcare organisations can work towards developing and enhancing the work environment so that staff are supported for these types of rare events.

Conclusion

A key motivation for this training day was to equip clinicians with skills that would support the mental preparation associated with recognising the indication and initiating the procedure promptly.

The HTA provided not only a deconstruction of this rare clinical procedure but also some of the conditions required at each step (O'Connor & O'Dea, 2025). This has implications when considering an organisation's readiness to respond. The identification of these initial systems considerations provided additional information that although drawn from one source, together with the HTA results offers a basis for further exploration of organisational, cognitive, and decision-making elements in subsequent stages of this work. These results will be used for the development of an in-situ simulation session, scheduled for 2026, designed to probe organisations' readiness to undertake this procedure. Furthermore, they will be used to inform the development of an interview guide to explore how the procedure is completed in practice by clinicians who have performed this procedure in a clinical setting, with the aim of building a knowledge repository that captures otherwise lost insights, supporting future clinicians who may need to perform this procedure.

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