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MINOR SURGERY IN MICRO-GRAVITY

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MINOR SURGERY IN MICROGRAVITY

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PURPOSE:

To investigate and demonstrate equipment and techniques proposed for minor surgery on Space Station Freedom.

OBJECTIVES:

- Test and evaluate methods of surgical instrument packaging and deployment.
- Test and evaluate methods of surgical site preparation and draping.
- Evaluate techniques of sterile procedure and maintaining sterile field.
- Evaluate methods of trash management during medical/surgical procedures.
- Gain additional experience in techniques for performing surgery in microgravity.

OVERVIEW:

A KC-135 parabolic flight test was performed on March 30, 1990 with the goal of investigating and demonstrating surgical equipment and techniques under consideration for use on Space Station Freedom (SSF.) The flight followed the standard 40 parabola profile with 20-25 seconds of near-zero gravity in each parabola. Four experimenters were involved in the study, two who were from practical clinical backgrounds, one biomedical engineer

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and one video-technician.

To accomplish the study the medical restraint system (MRS) was deployed as if for surgical use and the mini-racks were employed as the SSF Health Maintenance Facility (HMF) equipment-containing racks. A standard simple laceration scenario requiring suturing was used to step through the medical/surgical procedures, and in doing so highlighted the desired objectives of the study. The two clinical experimenters served as Crew Medical Officers (CMO's) 1 and 2, while the other two provided support and recording.

The sequence for the study was as follows (all procedures were first performed in the ground HMF lab to establish proficiency) :

- Parabolas 1-10: Deploy equipment tray(s)
Don sterile gloves
Prep arm using different methods
Drape with Incise drape
- Parabolas 11-20: Inject local anesthesia
Make incision and suture
Evaluate instrument restraints
Prep arm using different methods
Drape with paper fenestrated drapes
- Parabolas 21-30: Suture with OTS prepackaged instrument set
Drape with towels and clips
Suture using preferred methods
- Parabolas 31-40: Repeat of necessary steps.

BACKGROUND:

Several previous KC-135 microgravity investigations have been conducted regarding the capabilities needed to perform surgery in space. Most of these centered around the considerations for major surgery employing traditional methods of prepping, draping and gowning. Work has also gone forward in establishing the needs for patient and operator restraint. For the most part, these studies have confirmed that with proper restraint for the people and the equipment surgery can be performed in similar fashion as on Earth.

As would be expected, these studies also found that the more complicated the procedure became (such as in major surgery with extensive gowning and draping), the more difficult the situation was to manage in zero-gravity. At the conclusion of these studies, several areas of investigation remained including techniques for minor surgery, hemostasis and fluid management, and sterile field techniques.

The focus of the present study was to build on the previous efforts by considering the support needed to conduct simple minor surgical procedures. This sort of event is considered by some to be much more likely on SSF than elective or trauma surgery. Indeed, the current planning for SSFHMF in the area of surgery is directed mostly in support of the more common and immediate types of procedures that are encountered in standard medical practice. However, this study is also directed at continuing the foundation of knowledge and expertise required to develop the sort of medical/surgical support that will be needed for long term space exploration and colonization.

MATERIALS:

- Prototype MRS with restraints
- Mini-racks with stowage drawers
- Instrument tray with attachments
- Training suture arm (mannequin arm)
- Waste containers - dry, wet, sharp
- Drapes - Incise adhesive, paper fenestrated, towels with clips
- Suture sets - disposable off-the-shelf, custom (needle holder, iris scissors, adson forceps, suture scissors, curved mosquito clamps, towels clips, skin retractors, scalpel)
- Metal tray, magnetic mat
- Prep sponges (betadine swabsticks, betadine wipes, alcohol wipes, Frepps, iodoform sponges, Durapreps)

- Gauze, tape, syringes, gloves
- Support materials (tape, cords, towels, etc.)
- Video camera

PERSONNEL AND SUPPORT:

- 4 Investigators (two CMO's, one support, one recorder)
- Video recording performed by recorder; still photography performed by non-dedicated NASA photographer. Post-flight worksheets completed by all.

TEST PROTOCOL: (See "Flight Worksheet" appendix.)

RESULTS AND DISCUSSION:

Instrument Deployment and Restraint

Several different methods of instrument deployment and restraint were used during the flight. To begin with, a metal tray was attached in a secure manner to one end of the MRS. This tray served as a non-sterile attachment point. Initially a sterile wrapped minor surgery kit (custom made) was secured to the tray using simple clamps (see photo 1.) The sterile wrapping was carefully folded back while avoiding contact with the contents and inner surface. These flaps were secured to the undersurface of the restraint tray using clamps for half of the flaps, and adhesive material for the other half. This method of deployment functioned very well, but required a mechanism to secure the sterile kit AND the wrapping to the tray.

Through careful deployment as described, the inner contents of the surgery kit were exposed in a sterile manner. The kit was custom made with two types of surface: 1) a magnetic mat ("Mag Mat" - plastic mat containing magnetic strips) was glued to half of the kit surface, and 2) a cardboard surface with evenly spaced elastic bands was attached to the other half of the kit. In this manner the metallic instruments could be held against the magnetic surface, and the other materials such as gauze and syringes could be secured with the elastic bands. This functioned very effectively. CMO2 was able to present sterile supplies and instruments to the gloved CMO1,

who then could restrain these items to the kit surfaces. It was possible to gently propel the metallic instruments towards the Mag Mat in zero-G and have the Mag Mat "capture" the instrument. This method of instrument restraint proved to be the preferred method.

A second type of instrument restraint was tried using an off-the-shelf disposable suture set (see photo 2.) The thin plastic container for this suture set was placed against the Mag Mat to determine if the metal instruments would hold the kit against the mat. This did occur, but the hold was tenuous and any jostling or removal of instruments caused the restraint to be broken (see photo 3.)

It was felt that the best arrangement for instrument deployment and restraint would provide a mechanism for securely holding the instrument kit while exposing the contents in a sterile manner (which will require an additional mechanism for holding down the wrappings.) This should remain as simple as possible and should be able to be performed by a non-gloved individual. The instrument kit surface itself worked best by providing an open magnetic area for the instruments and an area with some sort of elastic bands or clips to hold miscellaneous supplies. It was noted that with the elastic bands, a variety of lengths and widths should be provided to accommodate different sized supplies. Whenever a larger item was restrained under a band, any previously placed smaller items would tend to float free. An open magnetic area for instrument restraint was preferred over a mechanism of groves or clips for two reasons: 1) the instruments could be placed randomly without effort to fit them into specific locations or grooves, and 2) the open surface was easier to clean up during and after the procedure (which would be even more important if these kits are to be cleaned and repackaged for repeat use.)

Methods of Site Preparation

Four different methods of site preparation were investigated during the study: Surgical sponge with povidine solution, Betadine Swabsticks (package of three), Frepps, and Durapreps. All of these were provided in a sterile container. Since the purpose of this study was to investigate minor surgical techniques, only a small area of site prep was performed as appropriate for simple suturing.

1. The surgical sponge with povidine was adequate for the job and perhaps more than needed for a simple procedure. (See photo 4.) If the

area had been dirty and required more thorough cleansing, a sponge such as this would perform nicely (although a different type of soap may be preferred for tissue cleansing.) For maximum benefit, the sponge would require additional wetting which was viewed as a disadvantage compared to the other methods.

2. The Betadine Swabsticks functioned quite well and were the preferred method for a simple procedure. (See photo 5.) They were ready to use as soon as the package was opened, and there was no spillage of fluid from the package even with vigorous shaking.
3. The Frepps were functional and simple to use. (Not pictured.) However, they did require that the fluid package be ruptured and vigorous squeezing and maneuvering was necessary to propel the fluid into the sponge portion. Once the fluid made its contact through the sponge, the Frepp worked well and additional fluid continued to be present through the wicking action of the sponge.
4. The Durapreps were the most difficult to use. (See photo 6.) Without gravity, the effort needed to force the fluid into the sponge was too much, and in some cases, never accomplished successfully.

It is felt that for most simple surgical procedures to be performed on SSF, the site can be thoroughly cleaned using the available washing facilities, anesthesia provided in an appropriate manner (usually local), and the site can be prepped for sterile procedure using a very simple technique (such as the betadine swabsticks). This mirrors accepted practice in terrestrial emergency rooms and should be equally effective in space.

Methods of Site Draping

Three different methods of site draping were investigated during this study. Again, the intent was to evaluate support for minor surgery, and therefore only single unit drapes were employed to establish sterile field for the immediate site only.

1. Incise adhesive drapes were the preferred method. These are clear stretchable plastic drapes with an adhesive surface. (See photo 7.) They required some practice and familiarity to employ properly, and do require two people for placement (only one of whom needs to be gloved.) However, once the proper placement technique was accomplished, they proved to be the simplest to use and the most

effective. The transparent material provided good view of the whole surgical area, the elastic nature provided ready conformity to any surface, the adhesive surface eliminated the need for additional restraint, and the non-fenestrated surface allowed the surgeon to create the exact opening desired. (See photo 8.)

2. A fenestrated paper drape with adhesive tape under the four corners was tested. (See photo 9.) This provided acceptable function, but did not conform to the surface without gravity and the premade fenestration was too large. If something like this were to be used, it would need additional adhesive and a smaller premade opening (or none at all.)
3. Traditional sterile cloth surgical towels were used during one procedure (not pictured.) This method required for separate towels and towel clips. The technique was cumbersome to perform and the towels tended to intrude due to zero-gravity. Additional restraints would be required for this method, which is not recommended.

Methods of Waste Management

As an aside during the study, simple methods of waste management were employed and provided some comment:

1. Dry trash - (see photo 10.) was contained in the "fish trap" basket that has been used on many previous flights. This is a wire mesh basket with a spring loaded lid. Attached to the MRS, it is fairly easy to use although smaller items tended to escape due to the diameter of the mesh. It was also somewhat difficult to empty due to the loose contents, and might be more effective if some sort of liner was employed. It was noted that this container needed restraint both at the top to the MRS and the bottom to the floor if it was to be stable enough for easy use.
2. Wet trash - was contained in standard "zip-lock" bags. This seemed to work pretty well and after a couple uses could be closed off and placed in a more permanent container (or even the dry trash container.) The best method of restraint for these bags was not established (attempted were use of tape to the edge of the MRS and held to the MRS surface with an elastic band.) There was an obvious need for some sort of completely enclosed container that could be restrained near the MRS for disposal of wet trash (sponges, wipes, gauze, etc). It should be small or collapsible to minimize volume and more than one may be needed for

any given procedure.

3. Sharp trash - was provided by typical hospital "sharps containers." These were fairly large and cumbersome for the small volume of sharp items (needles and scalpels) used in a simple procedure. The revolving lids were fairly effective if the container was placed on its side, otherwise items tended to escape. It was obvious that a more elegant, smaller and simpler design would suffice for HMF use.

Observations on performing Minor Surgery

The actual surgical part of the study was quite simple to perform in zero-gravity. (See photo's 11 - 16.) Control of suture material and maintenance of sterile field was easier to accomplish than in terrestrial practice. Of critical importance was providing secure but comfortable CMO restraint to the MRS for a prolonged procedure. Once this was effected, the surgical technique was little different from that on earth. Lighting, exposure and hemostasis were concerns not investigated during this study.

During this flight test there were several previous findings confirmed:

1. Even the most simple surgical procedures will probably require two operators. Once the surgeon is gloved and restrained to the MRS, a second CMO is required to provide assistance and support for many aspects of the procedure often taken for granted on earth.
2. Donning sterile gloves is very difficult to perform unaided and should be considered a two-person procedure.
3. Restraint for the patient, surgeons and equipment are key issues and must be adequately resolved before any procedure can be safely performed.
4. CMO2 can function similarly to a surgical assistant by presenting the gloved CMO1 with instruments and supplies (using sterile technique.) Once all materials are provided, CMO2 can then don gloves to assist in the actual procedure. In more complicated procedures when both CMO's are involved, a third crewmember may be required to assist as the "circulating nurse" role.

NASA PHOTO REFERENCE

S90-36882 - 83
Suction and entrainment of surface fluids

S90-36869 - 71
Suction of fluids on 0-g

S90-36853 - 54
Demonstrating a cautery device in 0-g

S90-36873
Using the laminar flow/particle containment system

S90-36876
Spurting blood in 0-g

S90-36888 - 89
Suturing in 0-g

S90-36891
Making an incision in 0-g

RECOMMENDATIONS:

Additional study needs to be performed on lighting, exposure and hemostasis. As the information accumulates, the identified preferred methods and techniques should be assembled into integrated procedures for further study and confirmation. The composition of the surgical kits needs investigation. Concern over SSF air-particulate level and possible wound contamination needs follow-up and evaluation of possible containment-isolation chambers and laminar flow devices should continue.

Surgical equipment and techniques should be designed for simplicity and flexibility so they can be adapted to a wide variety of uses. This will be especially true if volume remains constrained and no method of cleaning and repackaging of instruments is supplied. Surgical procedures for SSF should be patterned after those seen in remote facilities and emergency rooms rather than hospital surgical suites, although serious attention must be given to provision and maintenance of sterile field and cleanliness in the dirty SSF environment. It is planned that as the resources for medical care

in space grow, a more developed surgical capability will evolve based upon the knowledge and experience gained from preparing for and performing minor surgery aboard SSF.