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ODS Report Writing Interface
Makes Our Reporting Simple and Better

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ABSTRACT

When we feel that a complex report cannot be generated directly from SAS®, we usually get the data or some report components prepared in SAS, and then use other software, such as MS Word or Excel, to finish the reporting job. This situation has been changed since SAS 9.2. Taking one of our routine reports as an example, this paper will illustrate some useful features that the ODS report writing interface has, how syntaxes are applied, and how a complicated report can be done with simple code. With this new tool, our complex reports can be generated by just running the SAS program, which is much smoother and more efficient.

KEYWORDS

Complex reports, ODS report writing interface, inline formatting.

BACKGROND

INTERMACS (Interagency Registry for Mechanically Assisted Circulatory Support) is a national registry for patients who receive mechanical circulatory support device therapy to treat advanced heart failure. All the data is collected online through the United Network for Organ Sharing (UNOS) in Richmond, Virginia; and all the analyses and reports are processed in the INTERMACS at the University of Alabama at Birmingham. We receive 36 SAS datasets from UNOS periodically, which include all kinds of information regarding mechanical heart transplantation.

The example used in this paper is the adverse event review report, which is sent to the doctors periodically for a review to verify if the stated events or causes are valid. The report is composed of two parts, on the top is the Patient Information Overview, and then followed by the Event Worksheets that correspond to the high-lighted events listed in the Patient Information Overview.

In a brief view of a sample report (see Appendix 1), you can see that it is not simple, not something which can be easily generated by SAS before versions 9.1. Besides the fancy layout of the report, some specifications make the programming interesting, such as:
1) The horizontal and vertical spaces of some items can be dynamically adjusted according to the different lengths of the values.
2) For certain character strings, special font formats (styles) are assigned according to variable value. And different font formats can be displayed in one table cell.

Before the ODS report writing interface is available in SAS, for situation like this, we use SAS to prepare the report data and generate some report components, and then outsource the display jobs to MS Word, or ACCESS by which the report is generated.

INTRODUCTION

Before showing how the report is generated, let's have a brief look at the two report writing tools, the ODS report writing interface ('the Interface' in the following text) and the inline formatting.

ODS Report Writing Interface

Every time the Interface is run, you will see a warning message in the log window (Figure 1). Since the Interface is in the phase of "preproduction" in SAS 9.2, you cannot find relevant documentations in the SAS Help window. But you can still find a lot of information online. The references of this paper will give you a good starting point.

```
WARNING: Data step interface is preproduction in this release.
```

Figure 1

DATA _NULL_ has been used for report writing in SAS for a long time. The ODS report writing interface is a great leap further. Its power comes from the combination of DATA _NULL_ and ODS. It fully applies ODS features such as proportional fonts, colors, images, and so on; while at the same time it provides very flexible placement capabilities, and takes great advantage of the rich programming features that the data step offers, such as conditional logic, formatting capabilities, by-group processing, arrays, etc. The Interface is object-oriented, which provides you with many useful methods to control how you want to display your information so that even the most rigid reporting requirements can be met easily. In this paper, only the programming points used in the application SAS code are discussed in detail.

Here is how the basic programming structure of the Interface is used.

```
ods listing close;
ods pdf notoc startpage=no style=printer_adj file="...\ReportName.pdf";

data _null_;
   set AE_Info;
   declare odsout adj();          ❶

   adj.table_start();             ❷
      adj.row_start();
         adj.format_cell(data: " Patient and Device Information",        ❸
         overrides: "just=l font_size=14pt backgroundcolor=cxccffff font_weight=bold");
      adj.row_end();
   adj.table_end();               ❹

   ...
run;

...

ods pdf close;
```

❶ Declare an ODS object:
   Two ways:
      i) declare odsout object;
         object = _new_ object ( );

      ii) declare odsout object ( );

   Here, "declare" (short form: dcl) is the key word for declaring an object; "odsout" is the key word (class name) for creating a class instance of ODS output object; and "object" is placeholder for any object variable name. The above two methods have the same effect. In the code above, "adj" is the object variable name. (The adverse event review process was called "adjudication" initially.)

❷ and ❹ Object methods used to set up a table:
   The syntax for an object to use methods:
      object.method (<optional argument>, ···, <optional argument>);

   In the above code, method table_start( ) starts a table. It is always coupled with method table_end ( ), which ends the table; the methods row_start( ) and row_end( ) work in the same way; and the method format_cell( ) works alone to define a cell.

❸ Method arguments:
   They define what contents and styles are used to display by a method.

   Here, the argument "data:" is to show the text " Patient and Device Information" in the cell; and the argument "override" indicates that 4 default style values will be reset in this cell.

Inline Formatting

The inline formatting syntax: escape character {function-name <argument-1 <argument-2 ... <argument-n>>>}

The inline formatting is a very useful ODS tool that applies formatting functions to define how the contents are displayed rather than using global or default styles. This tool is experimental in SAS 8.2, and is in production for all destinations in SAS 9.2. Here is an example in the report.

```
ods escapechar='^';            ❶

title "^{style [just=left preimage='···\INTERMACS_logo_.bmp']}"            ❷
     "^{nbspace 35} ^{style [font_size=19pt font_weight=bold font_style=italic] Medical Event Review Worksheet}"
     "^{newline} ^{style [just=right font_face=arial font_size=10pt] Event Date: before 4/1/2010}";
```

❶ To specify an escape character:
        The syntax: ods escapechar='escape-character';

        An escape character should not occur for any other uses in the code. For the inline formatting, it indicates
        that an inline formatting function follows. The functions and the specified contents are wrapped in curly
        brackets. Here, '^' is specified as the escape character.

❷ Inline formatting functions in the above statement:
        Style: Modifies the style of the current contents. "preimage=" argument imports an
                      image at the beginning of the title.
        Nbspace: Insert blank spaces.
        Newline: Start a new line.

Here is how the title is displayed in the report by running the above title statement:
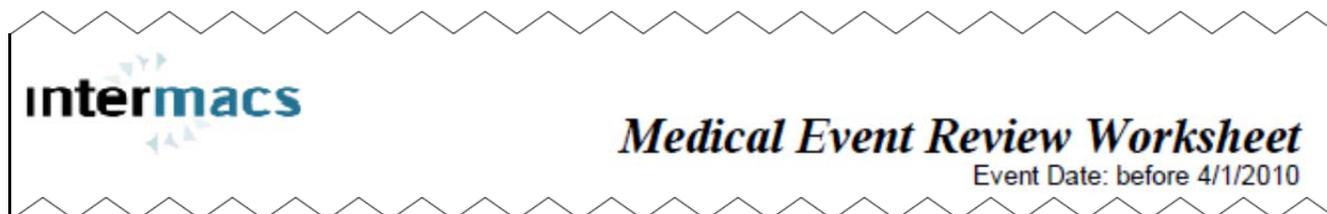

Figure 2

You can apply the inline formatting to any contents (inserted text or variable value) that you want to display in a report. The coding is simple, and it will make your report look great.

APPLICATION IMPLEMENTATION

The code to generate the report can be grouped into two parts: data preparation and report writing. The focus in this paper is the second part. However, to better understand the report writing, a brief description of the first part is helpful.

Data Preparation

After the data extraction and manipulation from raw datasets, two sets of data are generated: patient overall data and the adverse event data. Within each folder (see Figure 3 and 4), the small datasets are generated from two large datasets by Event_ID, which is postfix of each subset dataset name.

For example, the dataset "pt_12.sas7bdat" lists all relevant patient clinical events after the operation with Event_ID=12, ordered by the event date; while "ae_12.sas7bdat" holds the information of all adverse events sorted by event date after that operation, which are selected for the doctors to review.
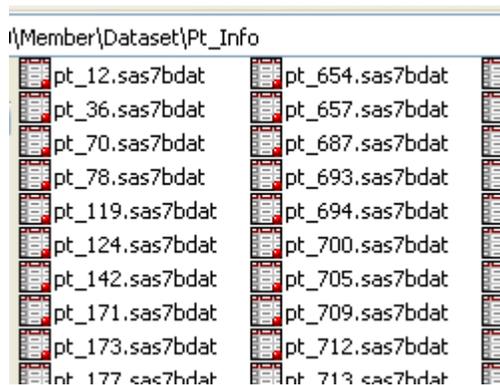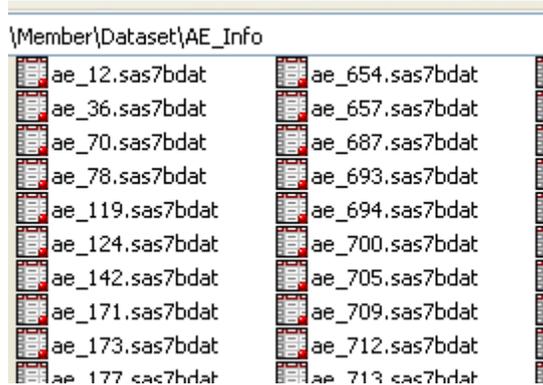
Figure 3   Figure 4

Report Writing

In the report writing code, DATA _NULL_ is the only SAS step repeatedly used to generate all the pieces of the report. Instead of going through the statements line by line, several helpful programming points are illustrated in this section. If you want to find a specific syntax in detail, please view the references.

1. Dynamic Spacing

If a reporting program uses the fixed display setting, sometimes it is not easy to set the right cell sizes or the right spaces between cells on a report sheet. The trouble is how to display all the values, and in the meantime to have a fine layout of the report contents if there exit a few extreme long strings for certain variable fields. If you want the report to look good, you may have to truncate those long values or rephrase them. Using the Interface, given the report setting and the length of variable value, if it is necessary, a new row will be inserted in the cell automatically until the entire value is displayed; or the horizontal spaces will be adjusted automatically in an optimal way.

Comparing the following two figures (Figure 5 and 6), you will see the effect in horizontal and vertical dimensions.
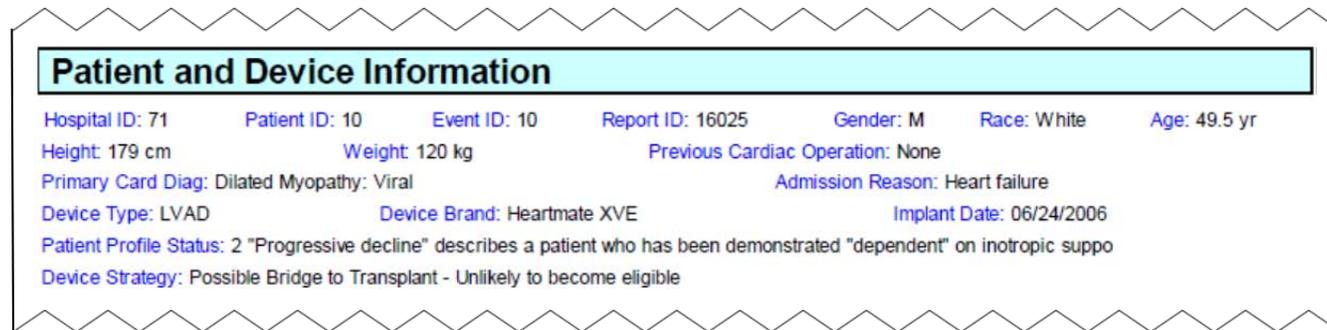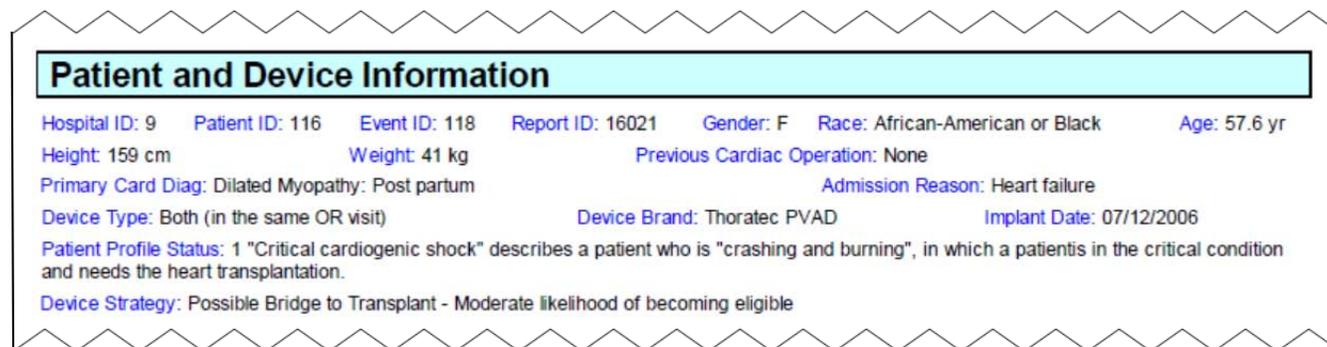

Figure 5

Figure 6

In Figure 6, the spaces between items in the first row are adjusted automatically due to the long Race value; and a new row is added due to the long Patient Profile Status value. The following is the corresponding code.

4

```
%macro insert1(label,var);                    ❶
adj.format_cell(data: "^{style [foreground=cx0000ff]&label: }"||strip(&var), overrides: "just=l");
%mend insert1;

%macro insert2(label,var,unit);              ❷
adj.format_cell(data: "^{style [foreground=cx0000ff]&label: }"||strip(&var)||" &unit", overrides:
"just=l");
%mend insert2;

%macro blkrow(height=1);                     ❸
adj.row_start();
   adj.format_cell(overrides: "cellheight=&height.mm");
adj.row_end();
%mend blkrow;

data _null_;
...

adj.table_start(overrides: "width=100pct borderwidth=0");
   %blkrow();

   adj.row_start();                          ❹
      %insert1(Hospital ID,Hospital_ID);
      %insert1(Patient ID,Patient_ID);
      %insert1(Event ID,Event_ID);
      %insert1(Report ID,Patient_Report_ID);
      %insert1(Gender,Gender);
      %insert1(Race,Race);
      %insert2(Age,Age,yr);
   adj.row_end();
adj.table_end();
...
run;
```

❶ A macro to insert the label in blue and variable value in black into a cell.

❷ A macro to insert the label in blue and variable value in black plus a unit name into a cell.

❸ A macro to insert a blank row with default height = 1mm.

❹ Putting all the cell into one row without setting "cellwidth" argument. By default, SAS will
   adjust them automatically. If you want to put them in fixed positions, you can do it by setting
   "cellwidth" values.

You do not see the specific coding for the adjusting effect, which is all done by SAS default. These little things
may turn out to be a big programming deal in other software packages, while SAS automatically does these for
you. What a relief!

2.   Generating Headers in DATA _NULL_
In SAS, if a procedure generates the resulting tables or lists longer than one page, the column headers will be automatically
added on the top of every new page, but this will not happen in DATA _NULL_ by default. However, we can still do it in the
following code, which inserts the headers as in Figure 7 on the top of every new page.

Figure 7

```
%macro Packet(Event_ID,N,pageLines);
...
%macro Pt_Info;
data _null_;
    set Pt_Info end=eof;
    if _n_=1 then declare odsout adj();

    if _n_=1 | mod(_n_,&pageLines)=&pageLines-1 then do;            ❶
    adj.table_start(overrides: "borderwidth=2");
        adj.row_start();
            adj.format_cell(data: "Event", inhibit: "LR",
            overrides: "font_weight=bold vjust=m cellwidth=11.2cm");
            adj.format_cell(data: "Event Date", inhibit: "LR",
             overrides: "font_weight=bold vjust=m cellwidth=3.7cm");
            adj.format_cell(data: "Submission|Status", split: "|", inhibit: "LR",         ❷
             overrides: "font_weight=bold cellwidth=1.8cm");
            adj.format_cell(data: "Last|Saved", split: "|", inhibit: "LR",
             overrides: "font_weight=bold cellwidth=1.7cm");
        adj.row_end();
    adj.table_end();
    end;
...
run;
%mend Pt_Info;
...
%mend Packet;
```

❶ The trick here to put the column headers on the top of each page is the MOD( ) function on _N_ in the IF statement. First, I counted the number of rows in one page in a testing run, then set the macro variable &pageLines to that the number+1. So, if it is the top row of a page, the column headers will be inserted.

❷ The argument "split" specifies the symbol to break the data argument contents into two rows; the argument "inhibit" suppresses the border lines of a cell, for example, `inhibit: "LR"` means that the left and right border lines of the cell are suppressed.

3. Special Symbols
Special symbols are often appeared in reports. In our reports, we used some square check boxes, such as in Figure 8.

Based on the provided information:

I. Occurence of bleeding:

☐ I find no reason to question the existence of this bleeding episode as stated above.

☐ I do find reason to question the existence of this bleeding episode as stated above becuase:

Figure 8

Here is the code to use special symbols:

```
...
    adj.row_start();
        adj.format_cell(data: "^{style [font_size=13pt]  ^{unicode 2610}} ^{style        ❶
        [font_size=10pt]I find no reason to question the existence of this bleeding ....}",
        overrides: "just=l cellheight=0.78cm");
    adj.row_end();

    adj.row_start();
        adj.format_cell(data: "^{style [font_size=13pt]  ^{unicode 2610}} ^{style       ❷
```

```
      [font_size=10pt]I ^{style [font_size=9pt font_weight=bold
      foreground=maroon] do} find reason to question the existence of this bleeding ...:}",
      overrides: "just=l cellheight=0.78cm");
   adj.row_end();
...
```

❶ and ❷ We can use inline formatting UNICODE function to insert whatever special symbols available in Unicode list which has various symbols. Here, the Unicode 2610 stands for the square check box.

4.　Conditional Formatting

You may have noticed that in the "Event" column of the patient overall information sheet, some events stand out in a different format (blue and bold). It means that these events are selected for review.

Figure 9

Here is the code:

```
%macro Pt_Info;
data _null_;
...
      if fmt=1 then do;           ❶
         adj.format_cell(data: "^{style [font_weight=bold]"||strip(Event)||"}"||
         ' (Report ID: '||strip(patient_report_id)||')', inhibit: "LTR",
         overrides: "just=l vjust=t foreground=blue font_weight=light        ❷
         cellwidth=11.2cm cellpadding=0 url="||strip(LinkTo));
      end;
...
run;
%mend Pt_Info;
```

❶ The variable fmt is in the Pt_Event_ID datasets (see Figure 3), which indicates whether an event is going to be reviewed (fmt = 1: to be reviewed).

❷ By taking the advantage of data step, IF statement is used here to conditionally set the format for only the events to be reviewed. The style parameters in "data" and "overrides" arguments define the new format.

CONCLUSION

The ODS report writing interface is an excellent tool to handle the complex reports. Comparing with other approaches, the Interface makes the report generation process smoother and more efficient. It gets all the programming jobs done in SAS, a one-stop solution. Based on my experiences, the Interface programming is easy to learn and very productive. The coding process might be tedious sometimes, and proper use of macros can reduce the repetitions.

I agree with what Daniel O'Connor stated in his paper, "DATA _NULL_ report writing has long been an integral part of the custom report writing offered by SAS[sm], but with this newly updated ODS Report Writing technology in SAS[sm] 9.2, you will have the ability to produce reports that you have only dreamed about."[2]

REFERENCES

1. Appendix 2: Method Documentation (a list of object method syntaxes with brief examples), support.sas.com/rnd/base/datastep/dsobject/Power_to_show_documentation.pdf
2. Daniel O'Connor, The Power to Show: Ad Hoc Reporting, Custom Invoices, and Form Letters, Paper 313-2009, SAS Global Forum 2009, support.sas.com/resources/papers/proceedings09/313-2009.pdf
3. ODS Report Writing Interface, support.sas.com/rnd/base/datastep/dsobject/index.html

CONTACT INFORMATION

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Appendix 1.

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Patient Information Overview
(Event ID: 865)

Event	Event Date	Submission Status	Last Saved
Demographics	03/05/2008 (Data entry start)	Complete	12/31/2008
Pre-Implant	11/28/2007 (Decision Date)	Complete	01/22/2009
Quality of Life (Pre-Implant) - Not completed			01/22/2009
Trailmaking (Pre-Implant) - Not attempted			01/22/2009
Implant	11/30/2007	Complete	08/01/2008
1 Week Post-Implant	12/07/2007	Complete	08/01/2008
Implant Discharge	12/17/2007	Complete	08/04/2008
1 Month Post-Implant	12/30/2007 (Expected date)	Complete	08/01/2008
3 Month Follow-Up	02/12/2008	Complete	08/01/2008
Quality of Life (3-Month) - Not completed			08/01/2008
Trailmaking (3-Month) - Not attempted			08/01/2008
6 Month Follow-Up	05/06/2008	Complete	08/04/2008
Quality of Life (6-Month) - Completed			08/04/2008
Trailmaking (6-Month) - Not attempted			08/04/2008
AE Infection	06/23/2008		08/04/2008
Rehospitalization - Admission	06/23/2008		08/04/2008
Rehospitalization - Discharge	06/27/2008		08/04/2008
AE Bleeding	11/08/2008		04/07/2009
1 Year Follow-Up	11/25/2008	Complete	04/07/2009
Quality of Life (12-Month) - Not completed			04/07/2009
Trailmaking (12-Month) - Not attempted			04/07/2009
1.5 Year Follow-Up	05/28/2009	Complete	06/12/2009
Quality of Life (18-Month) - Not completed			06/12/2009
Trailmaking (18-Month) - Not attempted			06/12/2009
2 Year Follow-Up	12/17/2009	Complete	01/27/2010
Quality of Life (24-Month) - Not completed			01/27/2010
Trailmaking (24-Month) - Not attempted			01/27/2010
AE Bleeding (Report ID: 18618)	12/17/2009		01/27/2010
Rehospitalization - Admission	12/17/2009		01/27/2010
Rehospitalization - Discharge	12/22/2009		01/27/2010
AE Neuro Dysfunction (Report ID: 18619)	12/25/2009		01/27/2010
Rehospitalization - Admission	12/25/2009		01/27/2010
AE Bleeding (Report ID: 18619)	12/29/2009		01/27/2010
Rehospitalization - Discharge	12/31/2009		01/27/2010
Psychiatric Episode	01/27/2010 (Report Date)		
2.5 Year Follow-Up	05/30/2010 (Expected date)	Incomplete	

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Medical Event Review Worksheet
Event Date: before 4/1/2010

Patient and Device Information

Hospital ID: 81   Patient ID: 912   Event ID: 865   Report ID: 18618   Gender: M   Race: White   Age: 68 yr
Height: 175 cm   Weight: 92 kg   Previous Cardiac Operation: CABG
Primary Card Diag: Dilated Myopathy: Ischemic   Admission Reason: Heart failure
Device Type: LVAD   Device Brand: Heartmate XVE   Implant Date: 11/27/2007
Patient Profile Status: 3 "Stable but Inotrope dependent" describes a patient who is clinically stable on mild-moderate dose
Device Strategy: Destination Therapy (patient definitely not eligible for transplant)

Event Report: **Bleeding**

Date of Event: 12/17/2009   Months Post-Implant: 24.5755   Patient Location: In hospital
Conditions Resulting from Bleeding: Episode resulted in transfusion
Transfusion Date: 12/19/2009
Bleeding Units: 2-3 units
Bleeding Source/Cause/Location: Lower gastrointestinal
Drug Intervention: N
Causative Factors: Complexities of Medical Management
Bleeding Factor Conditions:
Lab Tests: INR: 1.3   Test Date: 12/24/2009
PTT: 28   Test Date: 12/24/2009
PH: Test Date:
Anti-coagulation Therapy: None
Anti-coagulation Therapy - Other:

Adjudication Results

Based on the provided information:

I. Occurence of bleeding:

☐ I find no reason to question the existence of this bleeding episode as stated above.

☐ I **do** find reason to question the existence of this bleeding episode as stated above becuase:
_____

II. Causative or contributing factors to bleeding episode:

☐ I find no reason to question the factors related to this bleeding episode as stated above.

☐ I **do** find reason to question the factors related to this bleeding episode as stated above becuase:
_____

If you do not agree with the factor(s) above, please select causative or contributing factors to this bleeding (check all that apply):

☐ Poor compliance with monitoring anticoagulation therapy   ☐ Complexities of Medical Management
☐ Documented history of lesion or condition in the organ site   ☐ Procedural related to implant procedure
of bleeding that could potentiate a bleeding episode   ☐ Procedural related to any re-operative procedure
Name of condition: _____   ☐ Procedural related to any diagnostic procedure (e.g.
☐ Elevated preoperative INR or platelet count less than 60,000   bronchoscopy, endoscopy, or transesophageal echo)
☐ Management: Over anticoagulation   ☐ Unknown

Signation of Committee Member: _____   **Date:** _____

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Medical Event Review Worksheet
Event Date: before 4/1/2010

Patient and Device Information

Hospital ID: 81   Patient ID: 912   Event ID: 865   Report ID: 18619   Gender: M   Race: White   Age: 68 yr
Height: 175 cm   Weight: 92 kg   Previous Cardiac Operation: CABG
Primary Card Diag: Dilated Myopathy: Ischemic   Admission Reason: Heart failure
Device Type: LVAD   Device Brand: Heartmate XVE   Implant Date: 11/27/2007
Patient Profile Status: 3 "Stable but inotrope dependent" describes a patient who is clinically stable on mild-moderate dose
Device Strategy: Destination Therapy (patient definitely not eligible for transplant)

Event Report: Neurological Dysfunction

Date of Event: 12/25/2009   Months Post-Implant: 24.8383   Patient Location: Out of hospital

Neurological Category: Neurological Dysfunction - < 24 hours
Neurological Category - Other:
Causative Factor: Complexities of Medical Management
CNS Event: Intracranial Bleed
CNS Event - Other:
CNS Event Location: Left hemisphere
CNS Event Location - Other:
CNS Diagnosis Method: CT
CNS Diagnosis Method - Other:
Clinical Event: Stroke
Clinical Event - Stroke: Altered mental status
Clinical Event - Stroke - Other:
Surgical Intervention: N   Drug Intervention: Y   Drug Treatment: Thrombolytics
Contributes to Death: N

Adjudication Results

Based on the provided information:

I. Occurence of neurological dysfunction:

☐ I find no reason to question the existence of this neurological episode as stated above.

☐ I do find reason to question the existence of this neurological episode as stated above becuase:
_____

II. Causative or contributing factors to neurological dysfunction:

☐ I find no reason to question the factors related to this neurological episode as stated above.

☐ I do find reason to question the factors related to this neurological episode as stated above becuase:
_____

If you do not agree with the factor(s) above, please select causative or contributing factors to this neurological episode (check all that apply):

☐ Patient not taking anticoagulation medication properly
☐ If patient receiving warfarin then, evidence of INR above target range
☐ If patient receiving warfarin then, evidence of INR below target range
☐ If patient receiving heparin then, evidence of PTT above target range
☐ If patient receiving heparin then, evidence of PTT below target range
☐ Complexities of Medical Management
☐ Device Related
☐ Unknown

Signation of Committee Member:_____   Date:_____

Generated on: 05/07/2010   -- 3 --

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Medical Event Review Worksheet
Event Date: before 4/1/2010

Patient and Device Information

Hospital ID: 81   Patient ID: 912   Event ID: 865   Report ID: 18619   Gender: M   Race: White   Age: 68 yr
Height: 175 cm   Weight: 92 kg   Previous Cardiac Operation: CABG
Primary Card Diag: Dilated Myopathy: Ischemic   Admission Reason: Heart failure
Device Type: LVAD   Device Brand: Heartmate XVE   Implant Date: 11/27/2007
Patient Profile Status: 3 "Stable but inotrope dependent" describes a patient who is clinically stable on mild-moderate dose
Device Strategy: Destination Therapy (patient definitely not eligible for transplant)

Event Report: Bleeding

Date of Event: 12/29/2009   Months Post-Implant: 24.9697   Patient Location: In hospital
Conditions Resulting from Bleeding: Episode resulted in transfusion
                                    Transfusion Date: 12/29/2009
Bleeding Units: 2-3 units
Bleeding Source/Cause/Location: Lower gastrointestinal
Drug Intervention: Y
Causative Factors: Complexities of Medical Management
Bleeding Factor Conditions:
Lab Tests: INR: 1.3   Test Date: 12/29/2009
              PTT: 40   Test Date: 12/29/2009
              PH: Test Date:
Anti-coagulation Therapy: Warfarin; Aspirin
Anti-coagulation Therapy - Other:

Adjudication Results

Based on the provided information:

I. Occurence of bleeding:

☐ I find no reason to question the existence of this bleeding episode as stated above.

☐ I do find reason to question the existence of this bleeding episode as stated above becuase:
_____

II. Causative or contributing factors to bleeding episode:

☐ I find no reason to question the factors related to this bleeding episode as stated above.

☐ I do find reason to question the factors related to this bleeding episode as stated above becuase:
_____

If you do not agree with the factor(s) above, please select causative or contributing factors to this bleeding (check all that apply):

☐ Poor compliance with monitoring anticoagulation therapy
☐ Documented history of lesion or condition in the organ site
   of bleeding that could potentiate a bleeding episode
   Name of condition: _____
☐ Elevated preoperative INR or platelet count less than 60,000
☐ Management: Over anticoagulation
☐ Complexities of Medical Management
☐ Procedural related to implant procedure
☐ Procedural related to any re-operative procedure
☐ Procedural related to any diagnostic procedure (e.g. bronchoscopy, endoscoopy, or transesophageal echo)
☐ Unknown

Signation of Committee Member:_____   Date:_____

Generated on: 05/07/2010   -- 4 --