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Briefing to the OPTN Board of Directors on

Report Primary Graft Dysfunction in Heart Transplant Recipients

OPTN Heart Transplantation Committee

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Report Primary Graft Dysfunction in Heart Transplant Recipients

Data instrument Affected:	*Transplant Recipient Registration (TRR) form*
Sponsoring Committee:	*Heart Transplantation*
Public Comment Period:	*August 3, 2021 – September 30, 2021*
Board of Directors Date:	*December 6, 2021*

Executive Summary

Primary graft dysfunction (PGD) is the leading cause of 30-day mortality post-heart transplantation.[1] PGD also has a considerable negative effect on heart recipients' morbidity.[2] However, the Organ Procurement and Transplantation Network (OPTN) does not collect post-transplant information that could identify recipients who develop primary graft dysfunction. The OPTN Heart Transplantation Committee (hereafter, the Committee) proposes collecting post-transplant data at specific time intervals to identify PGD in heart transplant recipients and better assess the impact PGD has on recipient outcomes. This proposal intends to add the relevant data elements to the Heart Transplant Recipient Registration form (TRR).

This data collection proposal supports the OPTN strategic goal of improving waitlisted patient, living donor, and transplant recipient outcomes. The information collected will allow the Committee to monitor outcomes for recipients with PGD and the data collected will support evidence-based policy development in the future, which may include consideration of development of a continuous distribution heart allocation framework.

[1] Sanjeet Singh Avtaar Singh et al., "Primary Graft Dysfunction after Heart Transplantation: A Thorn amongst the Roses," *Heart Failure Reviews* 24, no. 5 (2019): 805-20.
[2] Jon Kobashigawa et al., "Report from a Consensus Conference on Primary Graft Dysfunction after Cardiac Transplantation," *The Journal of Heart and Lung Transplantation* 33, no. 4 (2014): 328.

Purpose

Primary graft dysfunction is considered to be fairly common after heart transplantation.[3] However, the OPTN does not currently collect post-transplant data that could help identify PGD. The lack of data limits the community's ability to identify the incidence of primary graft dysfunction among recipients as well as associated post-transplant outcomes. For instance, when the former OPTN Thoracic Committee[4] first considered a PGD project in 2014, there were concerns that there might be a rising incidence of PGD at that time. However, research studies suggest that it is difficult to determine whether there has been an increase or decrease.[5,6] Furthermore, it is difficult to know whether future allocation changes, such as considering the development of policy for the continuous distribution of hearts, may impact the rate of PGD. An understanding of the gravity of this problem is needed to inform future policy making.

This proposal intends to address this limitation by modifying the Heart TRR instrument to collect additional data elements relevant to identifying PGD in heart transplant recipients. This proposal also intends to remove the data element "Airway Dehiscence" from the post-transplant section of the TRR as this information is not relevant to heart recipients.

Background

PGD presents as ventricular dysfunction occurring within 24 hours post-transplant[7] where there is no identifiable secondary cause such as hyperacute rejection, pulmonary hypertension, or known surgical complications.[8] The 2013 International Society of Heart and Lung Transplantation (ISHLT) consensus conference established a classification system with a severity scale to enable a more valid and reproducible diagnosis of PGD and improve transplant program comparisons for incidence and treatment options.[9] **Appendix A** contains the ISHLT consensus statement and severity scale.

PGD is a leading cause of early mortality post-heart transplantation.[10] It also adds considerable morbidity to transplant recipients' outcomes, especially within the first year following transplant.[11] Despite PGD's impact, the Heart transplantation community lacks standardized diagnostic criteria that would allow for comparisons of mortality, morbidity, and incidence over time as well as between transplant programs.[12] For example, the ISHLT consensus conference cited several single-center studies reporting the incidence of PGD varying from 2.3 percent to 28.2 percent.[13] The conference participants found this to be symptomatic of the wide range of views held about the matter.

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[3] Jon Kobashigawa et al., "Report," 327-40.
[4] The OPTN Heart Transplantation Committee was officially created on July 1, 2020, and work before that time was performed by the OPTN Thoracic Organ Transplantation Committee. "Committee" in this proposal means either the Thoracic Committee of the Heart Committee depending on that point in time. OPTN, Notice of OPTN Policy, Bylaw, and Guidelines Changes, *Creation of OPTN Heart and Lung Committees*. https://optn.transplant.hrsa.gov/media/3721/thoracic-split-policy-notice-march-2020.pdf (Accessed June 23, 2021).
[5] Kobashigawa et al., "Report," 328.
[6] Quader et al., "Primary Graft Dysfunction after Heart Transplantation: Outcomes and Resource Utilization," 1520.
[7] Kobashigawa et al., "Report," 337.
[8] Kobashigawa et al., "Report."
[9] Kobashigawa et al., "Report," 327-40.
[10] Singh et al., "Primary Graft Dysfunction," 805-20.
[11] Kobashigawa et al., "Report," 328.
[12] Kobashigawa et al., "Report," 328.
[13] Kobashigawa et al., "Report."

Following the conference, the heart transplantation community has sought to further clarify PGD's reach and impact on recipient mortality, morbidity, and incidence. The ISHLT consensus statement defined severe PGD as the need for mechanical circulatory support following transplantation. The use of such support usually means longer ICU stays, more complications, slower recovery, longer hospitalizations, more need for rehabilitation, or additional prolonged care. A study applying the 2013 ISHLT consensus classification showed that severe PGD is associated with poor outcomes.[14] This two-center study described a 518 patient cohort with a 14 percent prevalence of PGD and a mortality of 54 percent in patients with severe PGD.[15]

Another study evaluating the outcomes of a different cohort of 195 patients found worse 30-day and one-year mortality in patients transplanted who developed moderate and severe PGD, as defined by ISHLT criteria, compared to those diagnosed with mild PGD or no PGD.[16] The patients also experienced increased intensive care unit (ICU) length of stays, postoperative bleeding, and infections. A consortium of Virginia cardiac transplant programs also examined outcomes and resource utilization following the development of PGD using the ISHLT definition.[17] Of the 718 patients studied, 15.3 percent developed PGD and these patients had longer ICU length of stays, longer duration of intubation, more multi-organ failure, and higher mortality.

Two recent studies from Canada and the United Kingdom also applied the use of the ISHLT PGD criteria to outcomes. In 2019, a study of a 412 patient cohort at the University of Toronto reported significantly elevated hazard ratios of 7.0 and 15.9 for one-year mortality for patients with moderate and severe PGD, respectively.[18] Similarly, a 2019 study examined the incidence, risk factors and outcomes following PGD in all adult heart transplant patients in the United Kingdom from October 2012 to October 2015 using the ISHLT consensus definition[19]. For the 450 adults included in this study, the incidence of PGD was 36.2 percent with an increased one-month mortality that was highest in the severe PGD group.

In addition to its affect on mortality, PGD adds considerable morbidity to transplant recipients' outcomes, especially within the first year following transplant.[20] For instance, the need for mechanical support post-transplant usually means longer ICU stays, more complications, slower recovery, longer hospitalizations, more need for rehabilitation, or additional prolonged care.

[14] Mario Sabatino et al., "Clinical Relevance of the International Society for Heart and Lung Transplantation Consensus Classification of Primary Graft Dysfunction after Heart Transplantation: Epidemiology, Risk Factors, and Outcomes," *The Journal of Heart and Lung Transplantation* 36, no. 11 (2017): 1217-225.
[15] Sabatino et al., "Clinical Relevance."
[16] John Squiers et al., "Application of the International Society for Heart and Lung Transplantation (ISHLT) Criteria for Primary Graft Dysfunction after Cardiac Transplantation: Outcomes from a High-volume Centre," European Journal of Cardio-thoracic Surgery 51, no. 2 (2017): 263-70.
[17] Mohammed Quader et al., "Primary Graft Dysfunction after Heart Transplantation: Outcomes and Resource Utilization," *Journal of Cardiac Surgery* 34, no. 12 (2019): 1519-525.
[18] Farid Foroutan and Heather J. Ross, "Primary Graft Dysfunction: The Devil Is in the Details," *Transplantation* 103, no. 2 (2019): 229-30.
[19] Sanjeet Singh Avtaar Singh et al., "ISHLT Primary Graft Dysfunction Incidence, Risk Factors, and Outcome: A UK National Study," *Transplantation* 103, no. 2 (2019): 336-43.
[20] Kobashigawa et al., "Report," 328.

Many donor, recipient, and procedural risk factors have been found to be associated with the development of PGD.[21] These include donor age, recipient age, recipient inotropic support, and pre-transplant mechanical support.[22] Ischemia time is also considered an independent risk factor.[23] Nonetheless, it is difficult to definitively establish the risk factors, according to researchers, because of the variability in the studies that have been performed.

In August 2020, the Committee identified PGD as a high priority project and sought to identify the most important parameters needed to identify PGD. They acknowledged that current data collection efforts were inadequate to actually define PGD based on the 2013 ISHLT consensus definition. The Committee developed an initial list of post-transplant data elements and collection timeframes. The list was shared with the community as a request for feedback document during the Winter 2021 public comment period. Public feedback was largely supportive of the proposed data elements, and commenters offered several ideas about the collection timeframes. The Committee incorporated these considerations in the recommended data elements included in this proposal.

Data collection that accurately captures the incidence of PGD will enable the heart transplant community to better assess the impact PGD has on the morbidity and mortality of heart transplant recipients. Information collected as part of this initiative will be used to develop future policy options. Furthermore, PGD-specific data may be beneficial to the Committee as it develops a continuous distribution allocation framework, which is expected to begin in 2023.

Throughout the development of the proposed list of data elements, the Committee requested input and guidance from the OPTN Data Advisory Committee (DAC), which ultimately endorsed this project. The DAC is responsible for monitoring and maintaining all OPTN data to ensure its accuracy, completeness, timeliness, and relevance. The DAC reviewed this data collection proposal to ensure that the data elements proposed for addition were aligned with the OPTN Principles for Data Collection, specifically to allow the OPTN to "develop transplant, donation, and allocation policies."[24]

Proposal for Board Consideration

The proposal will modify the current Heart TRR by adding the new data elements identified in **Table 1**. The data will be collected by transplant programs on all heart transplant recipients at 24 and 72 hours (plus/minus 4 hours) after the recipient arrives in the ICU. The table below also outlines the values or ranges associated with the data elements as well as the rationale for inclusion.

[21] Alina Nicoara et al., "Primary Graft Dysfunction after Heart Transplantation: Incidence, Trends, and Associated Risk Factors," *American Journal of Transplantation* 18, no. 6 (2018): 1466.
[22] Nicoara et al., "Primary Graft Dysfunction after Heart Transplantation: Incidence, Trends, and Associated Risk Factors.," 1466.
[23] Nicoara et al., "Primary Graft Dysfunction after Heart Transplantation: Incidence, Trends, and Associated Risk Factors."
[24] OPTN Data Advisory Committee, *Principles for Data Collection*, https://optn.transplant.hrsa.gov/members/committees/data-advisory-committee/ (accessed October 21, 2021).

Table 1: Proposed Data Elements for Addition to the Transplant Recipient Registration Form (TRR) Associated with Primary Graft Dysfunction (PGD)

Data Element	Values	Description / Rationale
Is Primary Graft Dysfunction (PGD) present?	Yes, No, Unknown	PGD refers to graft dysfunction occurring immediately after transplant, requiring greater than typical medical support, or mechanical support. PGD is graft dysfunction not attributable to hyperacute rejection, acute rejection, antibody mediated rejection, surgical implant issues, or acute infarction. Data collection may help identify and understand post-transplant morbidity and mortality impact. The question will be answerable at 24 hours and 72 hours, but will not be associated with any specific timeframe.
PGD – Left Ventricle (PGD-LV)	Yes, No, Unknown	If "Is PGD present?" is answered "No," then PGD-LV will not appear for the transplant program to complete. PGD-LV includes left failure. PGD-LV is defined by common society standards, and the presence of PGD-LV can be determined using imaging and/or hemodynamics (e.g.: low ejection fraction (LVEF), cardiac index < 2.0). The question will be answerable at 24 hours and 72 hours, but will not be associated with any specific timeframe.
PGD – Right Ventricle (PGD-RV)	Yes, No, Unknown	If "Is PGD present?" is answered "No," then PGD-RV will not appear for the transplant program to complete. PGD-RV includes right ventricular failure. PGD-RV is determined using imaging and/or hemodynamics (e.g.: dilated hypokinetic right ventricle (RV) on echo, low ejection fraction (LVEF), central venous pressure (CVP)>15, CVP/pulmonary capillary wedge (PCW)>0.63, pulmonary artery pulsatility index (PAPi)<1.85, cardiac index (CI) under 2.0.) The question will be answerable at 24 hours and 72 hours, but will not be associated with any specific timeframe.

Data Element	Values	Description / Rationale
Left Ventricular Ejection Fraction (LVEF)	Drop-down list with the following options describing dysfunction: • Severely Depressed LV Function EF <30% • Moderately Depressed LV Function / EF ≥30%--<40% • Mildly Depressed LV Function / EF ≥40%--<50% • Normal LV Function / EF ≥50% • Unknown	LVEF is requested during two timeframes, if it is available. First timeframe starts when the recipient leaves the operating room to 24 hours after arrival at the ICU (Leaves Operating Room--≤24 hours (+/- 4 hours) after ICU arrival.) The first timeframe can include the operating room EF. Second timeframe at 24 hours (+/- 4 hours) after arrival at the ICU to 72 hours after ICU arrival (>24 hours--≤72 hours). The following definition is associated with LVEF in other OPTN data collection forms: The ratio of the volume of blood the heart empties during systole to the volume of blood in the heart at the end of diastole expressed as a percentage (typically normal is over 50% and abnormal below 50%). LVEF is the major component when determining LVD. The question will be answerable at 24 hours and 72 hours, but will not be associated with any specific timeframe.
Right Atrial Pressure (RAP)	mm Hg, Unknown	RAP is defined by common society standards. RAP is available from hemodynamic data.
Pulmonary Capillary Wedge Pressure (PWCP) or Left Atrial (LA) Pressure	mm Hg, Unknown	PWCP is defined by common society standards and is available from typical hemodynamic data. PWCP estimates left atrial pressure and left ventricular filling pressure, which are elevated when LVD is present. Some centers may measure LA pressure directly, and directly measured values are acceptable.
Pulmonary Artery (PA) Systolic Pressure Pulmonary Artery Diastolic Pressure	mm Hg, Unknown	PA systolic and diastolic pressures are commonly defined hemodynamic measurements. PA systolic and diastolic pressures are routinely and continuously measured after heart transplantation by use of a pulmonary artery catheter. PA systolic and diastolic pressures are typically elevated in LVD. Many pediatric programs do not use PA catheters. In such cases, an estimate of PA systolic pressure (echo-determined tricuspid valve regurgitant jet gradient + RA pressure) can be substituted for a directly measured PA systolic pressure.

Data Element	Values	Description / Rationale
Cardiac Output[25] (CO)	Liters / minute, Unknown	The following definition is associated with CO in other OPTN data collection forms: "The volume of blood pumped out of the heart. Cardiac output is expressed as volume of blood per unit time or liters per minute. Cardiac output can be calculated using the Fick method (oxygen consumption divided by arteriovenous oxygen difference) or by the thermodilution technique, using a Swan-Ganz catheter." CO is a standard measurement used when defining heart failure.
Support device	Yes, No, Unknown	Support device information is currently collected on OPTN's TCR and TRR forms as "Patient on life support? and/or "Patient on ventricular assist device?," where responses are yes or no for both. Obtaining this information is important because the need for a support device is the definition of severe PGD.
If yes, to support device	Right, Left, or Biventricular	If "Support Device" is answered "No" or "Unknown" then this data element will not appear for the transplant program to complete. PGD can occur in either ventricle, or both ventricles. Knowing the ventricle is important as the type of PGD based on the affected ventricle carries difference treatment options and different prognoses. Obtaining this information will help identify the incidence of PGD and also risk factors for each type of PGD and risks of the different support devices used.
Type of support device[26]	Drop down list of devices	If "Support Device" is answered "No" or "Unknown" then this data element will not appear for the transplant program to complete. Device type can reflect severity of PGD and each device type has unique management and complication profiles that could differently impact outcomes.

[25] Reported cardiac output will be used to calculate cardiac index in UNet℠.
[26] See **Appendix B** for the list of support devices.

Data Element	Values	Description / Rationale
Inotrope support	Drop down list of medications (Select all that apply) Dosings[27]	There is wide variety among transplant programs on the type and amount of inotrope support used routinely post-transplant and when PGD ensues. Data collection is necessary because such program-specific decisions can have a strong effect on patient outcomes. All heart transplant recipients are on inotropes following transplant. Comprehensively understanding the use of inotropes, along with the presence of PGD, may help with analyses of risk factors and patient outcomes.
Nitric Oxide following transplant	Yes, No, Unknown	Nitric Oxide is not always administered to treat PGD, but to treat a patient's pulmonary hypertension to prevent PGD or graft dysfunction and thereby may indicate PGD.
Epoprostenol following transplant	Yes, No, Unknown	Epoprostenol is not always administered to treat PGD, but to treat a patient's pulmonary hypertension to prevent PGD or graft dysfunction and thereby may indicate PGD.

The Committee deliberated about the primary graft dysfunction data element. Members discussed whether useful information would be captured when asking clinicians whether the candidate was experiencing PGD. For example, would transplant program staff interpret the question similarly and thus provide responses that could be analyzed consistently. It was also asked why the Committee needed such a question as well as requesting the hemodynamic measurements identified in the ISHLT statement establishing mild, moderate, and severe PGD. The members agreed on the importance of collecting both clinician-defined PGD and data-defined PGD. According to the Committee members, there might be discrepancies between cases that can be identified as severe PGD based on the collected data and cases that are identified by the clinicians. If a clinician believes PGD to be present, then he or she is likely to respond by way of devices or medication dosings that would be identifiable and helpful when analyzing the data in the future.

Table 2 provides additional detail into the inotrope and vasopressor dosing ranges proposed for collection. Transplant program staff entering the data in the TRR will have the ability to select the dosing range that best represents their candidate be selecting from a drop-down list of the ranges. For the identified vasopressors, transplant programs will be able to choose between the different units of measurement shown in **Table 2**. The Heart Committee identified this as an opportunity to make reporting easier for programs, and the values will be reportable using drop-down lists on the TRR form.

[27] See Table 3: List of Inotropes and Vasopressors Ranges To Be Collected for Inotrope Support.

Table 2: List of Inotropes and Vasopressors Ranges To Be Collected for Inotrope Support

Inotrope	Dose (mcg/kg/min)	Dose (mcg/min)	Recommended Changes
Epinephrine	• None • Low (>0.00 – ≤0.05) • Moderate (>0.05 – ≤0.10) • High (>0.10) • Unknown	---	Add this to Inotrope data element
Milrinone	• None • Low (>0.00 – ≤0.30) • Moderate (>0.30 – ≤0.50) • High (>0.50) • Unknown	---	Add this to Inotrope data element
Dobutamine	• None • Low (>0.00 – ≤3.00) • Moderate (>3.00 – ≤7.50) • High (>7.50) • Unknown	---	Add this to Inotrope data element
Dopamine	• None • Low (>0.00 – ≤3.00) • Moderate (>3.00 – ≤7.50) • High (>7.50) • Unknown	---	Add this to Inotrope data element
Vasopressor	**Dose (mcg/kg/min)**	**Dose (mcg/min)**	**Recommended Changes**
Levo (Norepinephrine – Levophed)	• None • Low (≤0.05) • Moderate (>0.05 – ≤0.10) • High (>0.10) • Unknown	• None • Low (≤5.00) • Moderate (>5.00 – ≤12.00) • High (>12.00) • Unknown	Add this to Inotrope data element
Neo (Phenylephrine – Neosynephrine)	• None • Low (≤1.50) • Moderate (>1.50 – ≤4.00) • High (>4.00) • Unknown	• None • Low (≤100.00) • Moderate (>100.00 – ≤200.00) • High (>200.00) • Unknown	Add this to Inotrope data element
Vasopressor	**Dose (mcg/kg/min)**	**Dose (unit per minute)**	**Recommended Changes**
Vaso (Vasopressin – Pitressin)	---	• None • Low (≤0.05) • Moderate (>0.05 – ≤0.08) • High (>0.08) • Unknown	Add this to Inotrope data element

The Committee acknowledged that inotropes are most commonly administered in micrograms per kilograms per minute (mcg/kg/min) while vasopressors are commonly administered in micrograms per

minute (mcg/min). Levo is commonly administered in both units and the data collection instrument will allow the entry in the user's preferred unit.

As supported by the community, the Committee is proposing ranges for inotrope and vasopressor dosing to allow easier reporting. The ranges are intended to indicate a high, medium, and low dose of each therapy. The Committee determined these ranges by referencing how high dose inotropes are described in existing OPTN policy.[28] Other ranges were based on dosing recommendations provided in clinical reference handbooks.

Proposed removal from the Heart TRR

When reviewing existing data elements on the Heart TRR, the Committee identified "Airway Dehiscence" for potential removal because it is not relevant to heart transplants. There was no opposition to the removal of this data element from the TRR.

Overall Sentiment from Public Comment

The proposal was available for public comment from August 3 through September 30, 2021. The Committee requested feedback about the adequacy of the proposed data elements and proposed timing of data collection to identify PGD for future analysis. The Committee acknowledged throughout development of the proposal that the data collection could impact transplant program resources. The Committee took this concern very seriously and where possible, sought to make collection and reporting by the programs as straightforward as possible. They also requested feedback about the estimated level of effort that would be needed to provide the requested information, as well as ways to mitigate the resource impact the proposal might have on transplant programs. The Committee also requested feedback about whether the reporting ranges provided for the inotropes and vasopressors were appropriate for adult and pediatric candidates. Feedback was also requested about how best to ensure any differences between adult and pediatric recipients and PGD are captured.

The public comment proposal represents the Committee's second request for community input concerning the subject of PGD. During the January-March 2021 public cycle, the Committee submitted a Request for Feedback document for initial feedback on the overall data collection concept.

The following three primary themes emerged from the public comment period:

- Overall support for the proposal
- Data burden for transplant programs
- Consideration of pediatric and donor data elements

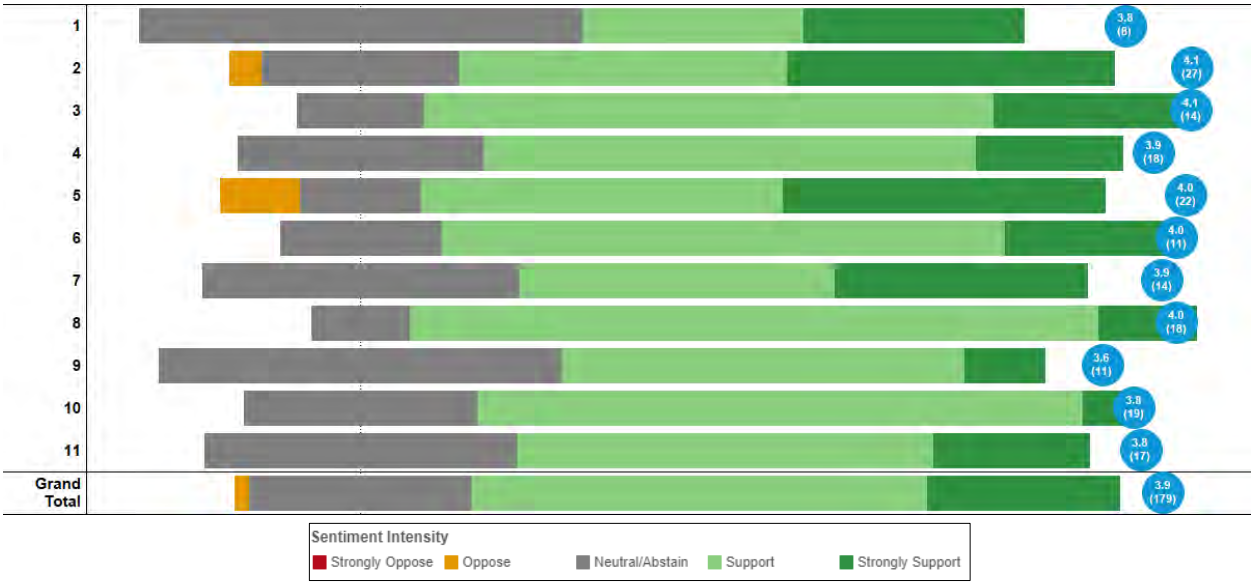
Each theme is discussed in more detail in this section.

[28] OPTN, *Policy 6.1.C.ii Multiple Inotropes or a Single High Dose Inotrope and Hemodynamic Monitoring*, https://optn.transplant.hrsa.gov/media/4190/bp_202012_guidance_addressing_use_ped_heart_exceptions.pdf (Accessed June 29, 2019)

Support for identifying the elements associated with PGD

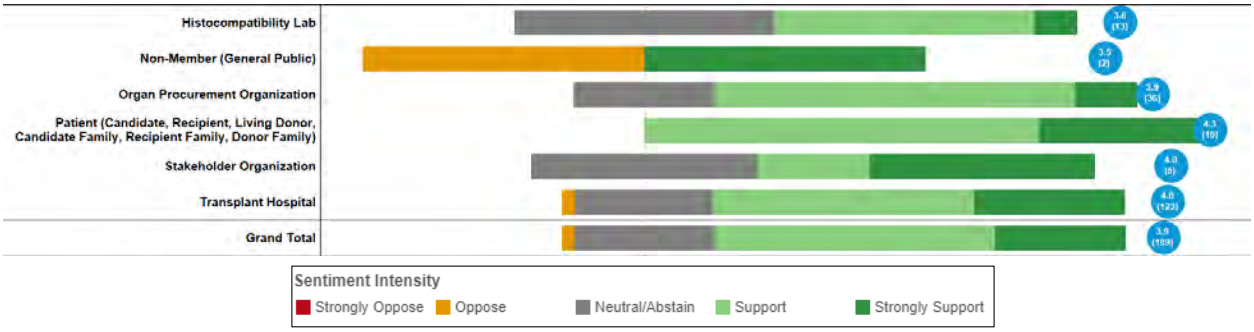
Figure 1 categorizes the sentiment information submitted as part of the 11 regional meetings.[29] As shown by the Grand Total bar, sentiment largely indicates support for the proposal within each region.

Figure 1: Sentiment Support for the Proposal, by Region



The proposal was also broadly supported across members types as demonstrated by the Grand Total bar shown in **Figure 2**.[30] During the regional meetings, a total of 131 members indicated support for the proposal while only three members indicated opposition to it. Sentiment was received from two non-members, with one indicating strong support for the proposal while the other was opposed.

Figure 2: Sentiment Support for the Proposal, by Member Type



[29] This chart shows the sentiment for the public comment proposal. Sentiment is reported by the participant using a 5-point Likert scale (1-5 representing Strongly Oppose to Strongly Support). Sentiment for regional meetings only includes attendees at that regional meeting. Region 6 uses the average score for each institution. The circles after each bar indicate the average sentiment score and the number of participants is in the parentheses.

[30] This chart shows the sentiment for the public comment proposal. Sentiment is reported by the participant using a 5-point Likert scale (1-5 representing Strongly Oppose to Strongly Support). Sentiment for regional meetings only includes attendees at that regional meeting. Region 6 uses the average score for each institution. The circles after each bar indicate the average sentiment score and the number of participants is in the parentheses.

Four professional organizations submitted written comments regarding the proposal. Their responses are summarized in **Table 3**. The American Society of Transplantation (AST) and the North American Transplant Coordinators Organization (NATCO) both indicated their support for the proposal.[31,32] The American Society of Transplant Surgeons' (ASTS) supported the concept of better defining PGD, but recommended an initial pilot project to establish the validity of the data proposed for collection.[33]

Table 3: Summary of Comments Provided by Professional Organizations

Organization	Summary of Comments
American Society of Transplantation	AST strongly supports the proposal to collect data on PGD.
American Society of Transplant Surgeons	ASTS is neutral on this policy proposal. ASTS supports the concept to better define PGD but recommends the OPTN facilitate a pilot project to vet and establish the validity of the proposed data elements before finalizing the policy.
North American Transplant Coordinators Organization	NATCO supports the proposed data elements and believes the data points of 24 hours and 72 hours are reasonable. The drop-down choices should help ease the data burden.
Pediatric Heart Transplant Society	PHTS agrees PGD is an important issue and appreciates that pediatric patients are considered. PHTS also wanted to ensure that certain concepts involving pediatric candidates were clarified and that the data collection be designed to answer specific questions resulting in meaningful outcomes.

Source: UNOS staff analysis of public comments submitted to the OPTN website during 08/03/2021 through 09/20/2021.

The Pediatric Heart Transplant Society (PHTS) appreciated the Heart Committee's consideration of pediatric candidates as part of the proposal, and suggested ways the Committee might be able to better capture pediatric-specific information for analysis.[34] After the public comment period ended, representatives from the Advanced Cardiac Therapies Improving Outcomes Network (ACTION) provided the Committee with similar feedback regarding the proposal and pediatric candidates.[35]

Input was also received from three OPTN Committees. The Data Advisory (DAC), Operations and Safety (OSC), and Transplant Coordinators (TCC) committees received presentations, and subsequently provided formal public comments about the proposal. All three committees supported the proposed data collection due to the potential for improving the transplant communities' understanding of PGD. However, both TCC and DAC also identified the potential increased data burden transplant programs may experience as a concern. DAC members recommended providing education to transplant program

[31] OPTN, Public Comment webpage, *Report Primary Graft Dysfunction in Heart Transplant Recipients*, American Society of Transplantation comments submitted September 29, 2021, https://optn.transplant.hrsa.gov/governance/public-comment/report-primary-graft-dysfunction-in-heart-transplant-recipients/#ProposalComments, (accessed October 1, 2021).
[32] OPTN, Public Comment webpage, *Report Primary Graft Dysfunction in Heart Transplant Recipients*, NATCO comments submitted September 29, 2021, https://optn.transplant.hrsa.gov/governance/public-comment/report-primary-graft-dysfunction-in-heart-transplant-recipients/#ProposalComments, (accessed October 1, 2021).
[33] OPTN, Public Comment webpage, *Report Primary Graft Dysfunction in Heart Transplant Recipients*, American Society of Transplant Surgeons comments submitted September 29, 2021, https://optn.transplant.hrsa.gov/governance/public-comment/report-primary-graft-dysfunction-in-heart-transplant-recipients/#ProposalComments, (accessed October 1, 2021).
[34] OPTN, Public Comment webpage, *Report Primary Graft Dysfunction in Heart Transplant Recipients*, Pediatric Heart Transplant Society comments submitted September 30, 2021, https://optn.transplant.hrsa.gov/governance/public-comment/report-primary-graft-dysfunction-in-heart-transplant-recipients/#ProposalComments, (accessed October 1, 2021).
[35] Email from representatives of ACTION to members of OPTN Heart Transplantation Committee, received on October 1, 2021.

staff about locating certain proposed data elements in a transplant recipient's record when the data must be identified manually.

In addition to data burden, TCC members also asked whether transplant programs would be required to perform testing needed to collect certain data elements in the proposal. For instance, a TCC member asked whether programs would be required to perform echocardiograms at 24 hours and 72 hours, even if the program had not intended to perform that testing.

The Committee greatly appreciated the feedback about testing and acknowledged clarification is needed. The Committee members stressed that the proposed data collection does not require programs to perform unnecessary or unplanned testing to collect the data, especially if it might result in greater risk to the patient's condition. Transplant programs are being asked to provide testing results if the results are available. When testing results are unavailable, programs will be able to indicate that as part of the data reporting process.

Data collection and reporting may increase transplant program's existing data burden

The Committee requested feedback regarding the level of effort transplant programs might experience with collecting and reporting the data. The potential data burden associated with the proposal was the community's biggest concern with the proposal. Multiple commenters indicated that transplant program staff could spend substantial amounts of time searching medical records for the many new data elements at the two time points requested. Despite these concerns, other respondents suggested that opportunities exist to substantially reduce collections time.

The Committee considered the arguments on both sides of the issue and ultimately decided to keep the proposed data elements and two reporting timeframes largely as they were in the public comment proposal. The Committee members based their decision on the potential benefits to heart transplant recipients of collecting the data, as well as the Committee's efforts to simplify the data collection and reporting as much as possible. The remainder of this section details the Committee's decision in light of the comments received.

Several public comment respondents cautioned that the large amount of data collection being proposed would negatively impact transplant programs. As part of the public comment proposal, the Fiscal Impact Group estimated that the proposed data entry would require transplant programs to spend an additional 30 to 60 minutes per Transplant Recipient Registration (TRR) form. The additional time was associated with program staff manually reviewing medical records to find certain information, such as where the presence or absence of PGD had been recorded. Several commenters cited the additional 30 to 60 minute estimate as part of their concern with increasing the existing level of effort programs face when collecting and reporting data. TCC members raised this concern as part of their public comment response. They were concerned that adding such a requirement to the increased workload from COVID-19 would unduly stretch program resources.[36]

[36] OPTN, Public Comment webpage, *Report Primary Graft Dysfunction in Heart Transplant Recipients*, OPTN Transplant Coordinators Committee comments submitted September 14, 2021, https://optn.transplant.hrsa.gov/governance/public-comment/report-primary-graft-dysfunction-in-heart-transplant-recipients/#ProposalComments, (accessed October 1, 2021).

The Committee reviewed all feedback following public comment. As they had been throughout the proposal's development, the Committee members were particularly interested in striking an appropriate balance between identifying the critical information necessary to understand PGD while not overburdening the transplant programs. It was pointed out that no post-transplant, heart-specific data are currently collected that can be used to better define the incidence, predictors, and outcomes of PGD. Given the impact PGD is believed to have on post-transplant mortality and morbidity, Committee members agreed that initiating the collection of such data in order to improve the care heart candidates receive outweighs the potential associated burden. Along those lines, OSC's support for the proposal acknowledged that the need to collect PGD data is long overdue.[37]

The Committee next considered whether PGD could be adequately tracked using fewer data elements. To answer the question, the Committee reviewed each data element and its associated rationale to make sure only the most useful information is collected. The Committee also considered whether each data element was an important component of the framework established by the ISHLT's consensus statement.[38] In addition, responses provided by AST and ASTS suggest the proposed data elements are appropriate for identifying PGD. AST commented that minimizing the data collection effort to reduce the data burden on programs is admirable, but may come at the expense of the greater granularity in understanding the outcomes of recipients who do not experience PGD.[39] The Committee's consensus was that all of the proposed data elements should remain.

Other respondents pointed out opportunities to lessen the impact of the proposed data gathering on transplant program. NATCO and ASTS acknowledged that the Committee's inclusion of drop-down choices for providing some of the data should help ease the data burden the forms would place on large transplant centers.[40,41] A regional meeting attendee indicated that the data elements identified in the proposal should be readily available in a patient's medical records and can be captured as part of a retrospective review. Some commenters said taking advantage of electronic data exchanges could also help lessen the burden on transplant programs.

Enhance pediatric and donor-specific information

In its written public comment, PHTS cautioned the Committee about some of the differences between pediatric and adult heart recipients, and how those differences might be addressed through data collection.[42] For example, the Committee's proposal states that pulmonary artery pressures are routinely and continuously monitored by the use of pulmonary artery catheters. PHTS pointed out that

[37] OPTN, Public Comment webpage, *Report Primary Graft Dysfunction in Heart Transplant Recipients*, NATCO comments submitted September 29, 2021, https://optn.transplant.hrsa.gov/governance/public-comment/report-primary-graft-dysfunction-in-heart-transplant-recipients/#ProposalComments, (accessed October 1, 2021).
[38] Kobashigawa et al., "Report."
[39] OPTN, Public Comment webpage, *Report Primary Graft Dysfunction in Heart Transplant Recipients*, AST comments submitted September 29, 2021, https://optn.transplant.hrsa.gov/governance/public-comment/report-primary-graft-dysfunction-in-heart-transplant-recipients/#ProposalComments, (accessed October 1, 2021).
[40] OPTN, Public Comment webpage, *Report Primary Graft Dysfunction in Heart Transplant Recipients*, OPTN Operations and Safety Committee comments submitted September 30, 2021, https://optn.transplant.hrsa.gov/governance/public-comment/report-primary-graft-dysfunction-in-heart-transplant-recipients/#ProposalComments, (accessed October 1, 2021).
[41] OPTN, Public Comment webpage, *Report Primary Graft Dysfunction in Heart Transplant Recipients*, American Society of Transplant Surgeons comments submitted September 29, 2021, https://optn.transplant.hrsa.gov/governance/public-comment/report-primary-graft-dysfunction-in-heart-transplant-recipients/#ProposalComments, (accessed October 1, 2021).
[42] OPTN, Public Comment webpage, *Report Primary Graft Dysfunction in Heart Transplant Recipients*, Pediatric Heart Transplant Society comments submitted September 30, 2021, https://optn.transplant.hrsa.gov/governance/public-comment/report-primary-graft-dysfunction-in-heart-transplant-recipients/#ProposalComments, (accessed October 1, 2021).

due to size constraints pulmonary artery catheters are not normally used to collect pulmonary pressures in pediatric candidates. PHTS proposed the use of other collection methods, such as echocardiogram parameters of right ventricle pressure or function.

Based on PHTS' comments and those of others, the Committee revised some of the data elements to account for the differences in pediatric and adult information. For example, the Committee members most experienced with pediatric heart transplantation informed the others about the alternatives methods that might be used to capture the pulmonary artery pressure of pediatric candidates. Members agreed to modify the pulmonary artery pressure data element so pediatric heart programs can submit an estimate of the pulmonary artery systolic pressure as a substitute for a direct measurement. The estimate can be obtained by using an echocardiogram-determined tricuspid valve regurgitant jet gradient added to the right atrial pressure measurement.

Additionally, the Committee agreed to revise the proposed pulmonary capillary wedge pressure data element to better accommodate pediatric candidates by allowing transplant programs to report left atrial pressure instead. Some transplant programs measure left atrial pressure directly, and the consensus of the Committee was that these directly measured values are acceptable for capturing information about pediatric patients.

In addition to the public comments addressing pediatric candidates, the Committee also reviewed the comments about including donor-specific data elements with the proposal. Commenters suggested that the Committee should collect information about Donation After Cardiac Death (DCD) donors due to the potential increased use of such donations. Public comments suggested identifying the type of perfusion used, warm and cold ischemic time, and the distance traveled by the organ.

The Committee had initially considered including donor-specific data elements as part of this proposal. In fact, the Request for Feedback document posted during the January-March, 2020 public comment cycle included a description of potential donor data. Given that this proposal was originally intended to obtain post-transplant data that the OPTN does not currently collect, and the potential to partner with other OPTN efforts to gather donor data, the Committee chose not to include such elements in the August, 2020 public comment proposal. Subsequent to public comment, the Committee considered addressing donor-specific data elements and determined it would not be appropriate to include them as part of this proposal given the feedback about increasing the data burden on transplant programs. Instead, the members recommended a separate project or collaboration with another OPTN committee to address collection of such data elements.

Compliance Analysis

NOTA and OPTN Final Rule

The Committee submits this proposal for Board consideration under the authority of the OPTN Final Rule, which states, "An organ procurement organization or transplant hospital shall, as specified from time to time by the Secretary, submit to the OPTN…information regarding transplant candidates, transplant recipients, [and] donors of organs..."[43] Additionally, the OPTN shall "[m]aintain records of all

[43] 42 CFR §121.11(b)(2).

transplant candidates, all organ donors and all transplant recipients"[44] and shall "…receive…such records and information electronically[.]"[45] As authorized by NOTA, the OPTN is required to "collect, analyze, and publish data concerning organ donation and transplants."[46] This proposal intends to add collection of PGD-related data elements on heart transplant recipients on Office of Management and Budget (OMB)-approved OPTN data collection instruments.

OPTN Strategic Plan

Improve waitlisted patient, living donor, and transplant recipient outcomes:

As previously mentioned, PGD is considered to be the leading cause of early mortality after heart transplantation, yet the heart transplantation community is still attempting to certain aspects of PGD. Such efforts have been stymied by the lack of a comprehensive dataset from which to analyze the problem. For example, the OPTN does not currently collect heart-specific post-transplant data associated with the factors believed to be associated with PGD. Furthermore, published research studies about PGD have largely been limited to reviews of single or multi-center experiences.

The proposed data collection contributes to the collective knowledge of effective organ transplantation. Specifically, the collected information will eventually allow the OPTN and the heart transplantation community to identify the components of PGD and analyze treatment trends. The Heart Committee will use the information to assist its policy development activities in the future.

OPTN Data Collection Principles

Develop transplant, donation, and allocation policies:

When considering the proposed data collection, the Committee reviewed the project's scope against the OPTN's Data Collection Principles.[47] The proposal was determined to align with principle to develop transplant, donation, and allocation policies because the collection of heart-specific PGD data elements will assist the Committee and eventually the transplant community in determining the impact PGD has on patient outcomes. The proposal also provided information that will aid in future policy development.

In addition, each data element the Committee considered was processed through the Data Element Standard of Review Checklist. In addition to their own experience with the identified data elements, the Committee members also relied on the professional clinical standards established through the ISHLT Consensus Conference Statement for PGD and the published PGD-literature findings based on single- and multi-center studies.

[44] 42 CFR §121.11(a)(1)(ii).
[45] 42 CFR §121.11(a)(1)(iii).
[46] 42 U.S.C. § 274(b)(2)(I).
[47] OPTN Data Advisory Committee, "Principles for Data Collection," https://optn.transplant.hrsa.gov/members/committees/data-advisory-committee/ (accessed October 21, 2021).

Implementation Considerations

Member and OPTN Operations

Operations affecting Histocompatibility Laboratories

This proposal is not anticipated to affect the operations of histocompatibility laboratories.

Operations affecting Organ Procurement Organizations

This proposal is not anticipated to affect the operations of organ procurement organizations.

Operations affecting Transplant Hospitals

This proposal will require transplant program staff to become familiar with the changes to the Heart TRR and data definitions. The additional data collection may require adjustments to existing workflows and require additional staff time for data entry.

Operations affecting the OPTN

This proposal will require programming in UNet℠ to update the existing Heart TRR form within Transplant Information Electronic Data Interchange® (TIEDI), an OPTN data entry system for transplant centers, OPOs, and histocompatibility laboratories across the county.

This proposal requires the submission of official OPTN data that are not presently collected by the OPTN. The OPTN Contractor has agreed that data collected pursuant to the OPTN's regulatory requirements in §121.11 of the OPTN Final Rule will be collected through OMB approved data collection forms. Therefore, after OPTN Board approval, the forms will be submitted for OMB approval under the Paperwork Reduction Act of 1995. This will require a revision of the OMB-approved data collection instruments, which may impact the implementation timeline.

Projected Fiscal Impact

This proposal is projected to have a fiscal impact on the OPTN and a minimal impact on transplant hospitals, but it is not anticipated to have any fiscal impact on organ procurement organizations or histocompatibility laboratories.

Projected Impact on Histocompatibility Laboratories

There is no expected impact for histocompatibility laboratories.

Projected Impact on Organ Procurement Organizations

There is no expected impact for OPOs.

Projected Impact on Transplant Hospitals

There is an expected minimal impact on transplant hospitals. Additional staff time will be required for training prior to implementation and additional staff time will be required for completing the transplant recipient registration form with the proposed data elements. Training is expected to require 1 to 2 hours

and the additional data entry is estimated to require an additional 30 to 60 minutes per form. Collecting and reporting on the proposed data elements is not expected to significantly alter existing processes or workflows.

Projected Impact on the OPTN

Policy and Community Relations (PCR) staff supported a Subcommittee in their proposal to update the reporting requirements for primary graft dysfunction (PGD). Currently the OPTN does not collect some relevant information which could assist in identifying patients at risk of PGD. This proposal required Committee meetings, leadership calls, drafting, review, post public comment revisions, and voting. Initial estimates reported this as a medium-sized project, and extra development hours were added to include the creation of new data elements for the TRR following review of public comment feedback. Similarly, IT noted 230 development hours were required to work on the proposed new TRR fields.

Additional implementation hours were also added to the PCR estimate to include the anticipated internal meetings with IT when creating TRR data elements.

IT anticipates a large implementation effort will be necessary, estimating 1556 implementation hours in order to add new TRR fields, new TRR elements, a new TRR element for support devices, and to remove the current field for airway dehiscence. This will require QA work from both PCR and Research.

Research will require 50 ongoing hours in order to monitor and summarize the newly collected data elements into a one year monitoring report. Similarly, IT estimates 153 hours will be necessary to monitor and provide updates as necessary.

Post-implementation Monitoring

Member Compliance

This proposal will not change the current routine monitoring of OPTN members. Any data entered into UNet℠ may be reviewed by the OPTN, and members are required to provide documentation as requested.

Data Collection Monitoring

The OPTN will analyze PGD-related metrics and outcomes as data become available, no more frequently than annually for two years after implementation. Timeline is subject to change based on the results. Data will be presented in tabular and graphical form as appropriate.

The following metrics, and any others subsequently requested by the Committee, will be evaluated as data become available:

- PGD data elements will be summarized using counts and percentages for categorical data elements and mean, median, interquartile range (IQR), minimum and maximum for continuous data elements.
- Incidence of PGD will be summarized overall and by de-identified center, OPTN region and DSA.
- Six-month patient and graft survival by PGD (left, right and overall) are subject to sample size.
- Distribution of donor characteristics (including DCD/non-DCD and machine perfusion) among recipients with and without PGD

Conclusion

Primary graft dysfunction has a substantial effect on the morbidity and mortality of heart transplant recipients. The OPTN does not currently collect post-transplant data related to PGD. The new data elements the Committee has proposed for addition to the Heart TRR form will provide valuable insights into the occurrence of PGD in heart recipients. The Committee understands that several years of data collection may be necessary before there will be enough data for an appropriate analysis to identify PGD in heart transplant recipients and assess the impact PGD has on recipient outcomes post-transplant. However, this data will allow the opportunity to have informed, evidence-based discussions when developing future policies.

Data Element Changes

1

Data Element	Values	Recommended Changes
Is Primary Graft Dysfunction (PGD) Present?	Yes, No, Unknown	Add this data element.
PGD – Left Ventricle (PGD-LV)	Yes, No, Unknown	Add this data element. The value will default to "No" if "Is Primary Graft Dysfunction (PGD) Present?" is "No" or "Unknown".
PGD – Right Ventricle (PGD-RV)	Yes, No, Unknown	Add this data element. The value will default to "No" if "Is Primary Graft Dysfunction (PGD) Present?" is "No" or "Unknown".
Left Ventricular Ejection Fraction (LVEF)	• Severely Depressed LV Function / EF <30% • Moderately Depressed LV Function / EF ≥30%--<40% • Mildly Depressed LV Function / EF ≥40%--<50% • Normal LV Function / EF ≥50% • Unknown	Add this data element. Transplant program chooses percentage from a drop down list with the values identified.
Right Atrial Pressure (RAP)	mm Hg, Unknown	Add this data element.
Pulmonary Capillary Wedge Pressure (PWCP) or Left Atrial (LA) Pressure	mm Hg, Unknown	Add this data element.
Pulmonary Artery (PA) Systolic Pressure	mm Hg, Unknown	Add this data element.
Pulmonary Artery (PA) Diastolic Pressure	mm Hg, Unknown	Add this data element.
Cardiac Output (CO)	Liters Per Minute, Unknown	Add this data element.
Support Device	Yes, No, Unknown	Add this data element.

Data Element	Values	Recommended Changes
If yes to Support Device	Right, Left, Biventricular, Unknown	Add this data element. The value will default to "Unknown" if "Support Device" is answered "No," or "Unknown".
Type of Support Device	Drop-down list of devices	Add this data element. The value will default to "Unknown" if "Support Device" is answered "No" or "Unknown".
Inotrope Support		Add this data element.
Nitric Oxide Following Transplant?	Yes, No, Unknown	Add this data element.
Epoprostenol Following Transplant?	Yes, No, Unknown	Add this data element.

2

Inotrope	Dose (mcg/kg/min)	Dose (mcg/min)	Recommended Changes
Epinephrine	• None • Low (>0.00 – ≤0.05) • Moderate (>0.05 – ≤0.10) • High (>0.10) • Unknown	---	Add this to Inotrope data element
Milrinone	• None • Low (>0.00 – ≤0.30) • Moderate (>0.30 – ≤0.50) • High (>0.50) • Unknown	---	Add this to Inotrope data element
Dobutamine	• None • Low (>0.00 – ≤3.00) • Moderate (>3.00 – ≤7.50) • High (>7.50) • Unknown	---	Add this to Inotrope data element
Dopamine	• None • Low (>0.00 – ≤3.00) • Moderate (>3.00 – ≤7.50) • High (>7.50) • Unknown	---	Add this to Inotrope data element

3

Vasopressor	Dose (mcg/kg/min)	Dose (mcg/min)	Recommended Changes
Levo (Norepinephrine – Levophed)	• None • Low (≤0.05) • Moderate (>0.05 – ≤0.10) • High (>0.10) • Unknown	• None • Low (≤5.00) • Moderate (>5.00 – ≤12.00) • High (>12.00) • Unknown	Add this to Inotrope data element
Neo (Phenylephrine – Neosynephrine)	• None • Low (≤1.50) • Moderate (>1.50 – ≤4.00) • High (>4.00) • Unknown	• None • Low (≤100.00) • Moderate (>100.00 – ≤200.00) • High (>200.00) • Unknown	Add this to Inotrope data element

4

Vasopressor	Dose (mcg/kg/min)	Dose (unit per minute)	Recommended Changes
Vaso (Vasopressin – Pitressin)	---	• None • Low (≤0.05) • Moderate (>0.05 – ≤0.08) • High (>0.08) • Unknown	Add this to Inotrope data element

5

6 #

Appendix A: ISHLT Consensus Statements on Primary Graft Dysfunction (PGD) and Definition of Severity Scale for PGD

Consensus Statements

1. Graft dysfunction is to be classified into PGD or secondary graft dysfunction where there is a discernible cause such as hyperacute rejection, pulmonary hypertension, or known surgical complications (e.g., uncontrolled bleeding).
2. The diagnosis of PGD is to be made within 24 hours after completion of the cardiac transplant surgery.
3. PGD is to be categorized into PGD-LV or PGD-RV.
4. A severity scale for PGD-LV will include mild, moderate or severe grades based on specified criteria.
5. Risk factors are categorized in terms of donor, recipient, or surgical procedural factors. Optimization of risk factors and improved allocation and matching of donors and recipients may result in decreased incidence of PGD.
6. Medical management with inotropic support should initially be instituted for PGD. The use of levosimendan may also be helpful. For PGD-RV, nitric oxide and phosphodiesterase inhibitors may be helpful.
7. Mechanical circulatory support of PGD such as ECMO is indicated when medical management is not sufficient to support the newly transplanted graft.
8. Retransplantation for severe PGD may be indicated in select patients if risk factors are minimal.
9. All patients in whom mechanical circulatory support is placed directly into the heart should have a biopsy performed at that time.
10. It was recommended that an autopsy should be performed in all patients who are diagnosed with PGD and subsequently expire.
11. Potential future studies include creation of a PGD registry, impact of preservation solutions on PGD, mechanistic studies to understand pathophysiology of PGD, and study of donor management to minimize PGD, among others.

Definition of Severity Scale for Primary Graft Dysfunction (PGD)

1. PGD Left ventricle (PGD-LV):	*Mild PGD-LV*: *One* of the following criteria must be met:	LVEF ≤ 40% by echocardiography, *or* Hemodynamics with RAP > 15 mm Hg, PWCP > 20 mm Hg, CI < 2.0 L/min/m^2 (lasting more than 1 hour) requiring low-dose inotropes
	Moderate PGD-LV: Must meet one criterion from I *and* another criterion from II:	I. *One* criteria from the following: Left ventricular ejection fraction ≤ 40%, *or* Hemodynamic compromise with RAP > 15 mm Hg, PCWP > 20 mm Hg, 20 mm Hg, CI < 2.0 L/min/m^2, hypotension with MAP < 70 mm Hg (lasting more than 1 hour) II. *One* criteria from the following: i. High-dose inotropes—Inotrope score > 10[a] or ii. Newly placed IABP (regardless of inotropes)
	Severe PGD-LV	Dependence on left or biventricular mechanical support including ECMO, LVAD, BiVAD, or percutaneous LVAD. Excludes requirement for IABP.
2. PGD-right ventricle (PGD-RV):	Diagnosis requires either both i and ii, or iii alone:	i. Hemodynamics with RAP > 15 mm Hg, PCWP < 15 mm Hg, CI < 2.0 L/min/m^2 ii. TPG < 15 mm Hg and/or pulmonary artery systolic pressure < 50 mm Hg, *or* iii. Need for RVAD

BiVAD, biventricular assist device; CI, cardiac index; ECMO, extracorporeal membrane oxygenation; IABP, intra-aortic balloon pump; LVAD, left ventricular assist device; PCWP, pulmonary capillary wedge pressure; RAP, right atrial pressure; RVAD, right ventricular assist device; TPG, transpulmonary pressure gradient.

[a] Inotrope score = dopamine (x1) + dobutamine (x1) + amrinone (x1) + milrinone (x15) + epinephrine (x100) + norepinephrine (x100) with each drug dosed in µg/kg/min.

Source: Jon Kobashigawa et al., "Report from a Consensus Conference on Primary Graft Dysfunction after Cardiac Transplantation," *The Journal of Heart and Lung Transplantation* 33, no. 4 (2014): 337-38.

Appendix B: List of Mechanical Circulatory Support Devices Associated with Certain Adult Heart Statuses

Dischargeable VADs	Non-Dischargeable VADs	Percutaneous Devices	Total Artificial Hearts
Evaheart	Abiomed AB5000	Biomedicus	AbioCor
Heartmate II	Abiomed BVS 5000	Cardiac Assist Tandem Heart	SynCardia CardioWest
Heartmate III	Berlin Heart EXCOR	Cardiac Assist Protek Duo	Other Specify
Heartsaver VAD	Biomedicus	CentriMag (Thoratec/Levitronix)	—
Heartware HVAD	CentriMag (Thoratec/Levitronix)	Impella Recover 2.5	—
Jarvik 2000	Maquet Jostra Rotaflow	Impella Recover 5.0	—
ReliantHeartAssist 5	Medos	Impella CP	—
ReliantHeart aVAD	PediMag (Thoratec/Levitronix)	Impella RP	—
Worldheart Levacor	Terumo Duraheart	Maquet Jostra Rotaflow	—
Other Specify	Thoratec IVAD	PediMag (Thoratec/Levitronix)	—
—	Thoratec PVAD	Other Specify	—
—	Toyobo	—	—
—	Ventracor VentrAssist	—	—
—	Other Specify	—	—

Notes: There are no device brands for Venoarterial Extracorporeal Membrane Oxygenation (VA ECMO) or Intra-aortic Balloon Pump (IABP). The "Other Specify" category is included for instances where a candidate's device brand is not identified.
Source: OPTN website (accessed on June 29, 2021): https://optn.transplant.hrsa.gov/media/2457/heart_device_brand_background.pdf