Congenital Heart Surgery Nomenclature and Database Project: ventricular septal defect

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The extant nomenclature for ventricular septal defect (VSD) is reviewed for the purpose of establishing a unified reporting system. The subject was debated and reviewed by members of the STS-Congenital Heart Surgery Database Committee and representatives from the European Association for Cardiothoracic Surgery. All efforts were made to include all relevant nomenclature categories using synonyms where appropriate. Four basic VSD types are described: Subarterial, Perimembranous, Inlet, and Muscular. A comprehensive database set is presented which is based on a hierarchical scheme. Data are entered at various levels of complexity and detail which can be determined by the clinician. These data can lay the foundation for comprehensive risk stratification analysis. A minimum database set is also presented which will allow for data sharing and would lend itself to basic interpretation of trends. Outcome tables relating diagnoses, procedures, and various risk factors are presented.

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I. Background

A ventricular septal defect (VSD) is defined as an opening or hole in the interventricular septum [1]. Isolated VSD occurs in approximately 2 out of every 1000 live births and constitutes over 20% of all congenital heart disease [2]. Perhaps because isolated VSD is the most commonly recognized form of congenital heart disease [3], numerous nomenclature schemes have been utilized to describe and classify this lesion. Three of the more commonly utilized VSD nomenclature systems will be presented.

Historically, VSDs have been assigned to one of four anatomic types [2]. Figure 1 represents a computer-generated diagram depicting this classic anatomic nomenclature. Type I VSDs are termed supracristal, infundibular, juxtaarterial, or conal. This defect lies caudad to the pulmonary valve in the infundibular portion of the right ventricular outflow tract. Type II VSDs are termed perimembranous or paramembranous and are located adjacent to the membranous portion of the ventricular septum and the septal leaflet of the tricuspid valve. Type III VSDs are termed inlet or atrioventricular canal VSDs and are located posteriorly at the inlet portion of the right ventricular septum (corresponding to the outlet portion of the left ventricular septum). Type IV VSDs are muscular defects and include a variety of single and multiple defects in the muscular septum.

Numerous surgeons utilize a classification scheme advocated by Robert Anderson [4–6]. Figure 2 represents a computer-generated diagram depicting this VSD nomenclature system. This classification divides VSDs into three main types: perimembranous defects which are bordered directly by the fibrous continuity between the atrioventricular (AV) valves and an arterial valve, muscular defects which are completely embedded in the septal musculature, and doubly committed juxtarterial defects which are bordered directly by the fibrous continuity of the leaflets of the aortic and pulmonary valves. The perimembranous and muscular defects are then subdivided into three subgroups, based on whether they mainly open into the inlet, trabecular, or outlet portion of the right ventricle (RV).

Van Praagh advocates a third nomenclature system that describes four main types of VSDs [7, 8]. Figure 3 represents a computer-generated diagram displaying this nomenclature system. In this system, VSDs are classified as AV canal type, muscular, conoventricular, or conal. AV canal type VSDs are defects in the AV canal portion of the ventricular septum beneath the tricuspid valve and limited by the tricuspid valve annulus. Muscular VSDs have a rim totally made up of muscle, and may occur anywhere in the muscular septum; these muscular VSDs may be subdivided into anterior, midventricular, posterior, and apical depending on their location in the muscular septum. Conoventricular defects include defects of the membranous septum alone, but most involve more than just the membranous septum, and are therefore termed paramembranous. (Van Praagh prefers the term paramembranous to perimembranous because these defects are beside the membranous sep-

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Fig 1. This computer-generated diagram depicts the classic anatomic nomenclature assigning VSDs to a one of four anatomic types [2].

tum and confluent with it, not surrounding the membranous septum on all sides). These conoventricular defects include malalignment conoventricular septal defects: anterior malalignment of the conal septum is seen in tetralogy of Fallot (TOF) and posterior malalignment is seen in interrupted aortic arch (IAA). Finally, conal septal defects result from a defect within the conal septum, are limited upstream by the pulmonary valve, and are otherwise surrounded by conal septal muscle.

II. Analysis: A Unified VSD Nomenclature System

Obviously, numerous variations on these three VSD nomenclature proposals exist. A picture is worth a thousand words, so computer generated images can be utilized to demonstrate how the various previously described nomenclature systems can all coexist and be interrelated. Figure 4 represents a computer-generated depiction of the ventricular septum. Figures 5, 6, and 7 epict each of the three VSD nomenclature systems described above mapped onto this computer-generated depiction of the ventricular septum. This exercise allows for the creation and understanding of the unified nomenclature system proposed below.

At first glance, this proposal may seem overly complex, but in reality, it is based on four basic VSD types: subarterial, perimembranous, inlet, and muscular. The myriad of other more detailed coding choices is extremely manageable with the use of computer-generated coding as described above. At any given level of coding, many surgeons might consider further description as irrelevant and simply stop at that level without further specification.

Fig 2. This computer-generated diagram depicts the VSD nomenclature system advocated by Robert Anderson [4–6].

Fig 3. This computer-generated diagram depicts the VSD nomenclature system advocated by Van Praagh [7, 8].

Fig 4. This diagram represents a computer-generated depiction of the ventricular septum.

Fig 5. This diagram depicts the classic anatomic nomenclature mapped onto the computer-generated depiction of the ventricular septum.

VSD Hierarchy Level 1

VSD

VSD Hierarchy Level 1 Definitions

VENTRICULAR SEPTAL DEFECT (VSD): An opening or hole in the interventricular septum.

VSD Hierarchy Level 2

VSD, NOS

VSD, **Multiple**
VSD, **Type 1 (Subarterial) (Supracristal) (Conal septal defect) (Infundibular)**
VSD, **Type 2 (Perimembranous) (Paramembranous) (Conoventricular)**
VSD, **Type 3 (Inlet) (AV canal type)**
VSD, **Type 4 (Muscular)**
VSD, **Type: Gerbode (Left ventricular to right atrial communication)**

VSD Hierarchy Level 2 Definitions

VSD, NOS: A VSD not further described (NOS = not otherwise specified). This designation allows for patient entries from other database schemes if no specific subtype is characterized or assigned.

VSD, MULTIPLE: More than one VSD exists. Each individual VSD may then be coded separately to specify the individual VSD types. (In this hierarchical system, if a VSD is coded and VSD, Multiple is not selected, the patient is coded as having a single VSD.)

VSD, TYPE 1: (Synonyms: subarterial VSD, supracristal VSD, conal VSD, infundibular VSD). A VSD that lies beneath the semilunar valve(s) in the conal or outlet septum [9].

VSD, TYPE 2: (Synonyms: perimembranous, paramembranous, conoventricular). A VSD that is confluent with and involves the membranous septum and is bordered by an atrioventricular valve, not including the type 3 VSDs (see below).

VSD, TYPE 3: (Synonyms: inlet, AV canal type). A VSD that involves the inlet of the right ventricular septum immediately inferior to the AV valve apparatus.

VSD, TYPE 4: (Synonyms: Muscular). A VSD completely surrounded by muscle.

VSD, TYPE: GERBODE TYPE: (Synonym: Left ventricle-right atrium (LV-RA) fistula). A rare form of VSD in

Fig 6. This diagram depicts the VSD nomenclature system advocated by Robert Anderson mapped onto the computer-generated depiction of the ventricular septum.

Fig 7. This diagram depicts the VSD nomenclature system advocated by Van Praagh mapped onto the computer-generated depiction of the ventricular septum.

which the defect is at the membranous septum; the communication is between the LV and RA.

VSD Hierarchy Level 3

VSD, NOS

VSD, Multiple, NOS

VSD, Multiple, **2 VSD**
VSD, Multiple, **3 VSD**
VSD, Multiple, **4 VSD**
VSD, Multiple, **5 VSD**
VSD, Multiple, **6 VSD**
VSD, Multiple, **More than 6 VSD**

VSD, Type 1 (Subarterial) (Supracristal) (Conal septal defect) (Infundibular), NOS

VSD, Type 1 (Subarterial) (Supracristal) (Conal septal defect) (Infundibular), **Conal Muscular**
VSD, Type 1 (Subarterial) (Supracristal) (Conal septal defect) (Infundibular), **Juxtaarterial**

VSD, Type 2 (Perimembranous) (Paramembranous) (Conoventricular), NOS

VSD, Type 2 (Perimembranous) (Paramembranous) (Conoventricular), **Inlet**
VSD, Type 2 (Perimembranous) (Paramembranous) (Conoventricular), **Trabecular**
VSD, Type 2 (Perimembranous) (Paramembranous) (Conoventricular), **Outlet**
VSD, Type 2 (Perimembranous) (Paramembranous) (Conoventricular), **Confluent**

VSD, Type 3 (Inlet) (AV canal type), NOS

VSD, Type 3 (Inlet) (AV canal type), **Associated with AV canal defect**
VSD, Type 3 (Inlet) (AV canal type), **Not associated with AV canal defect**

VSD, Type 4 (Muscular), NOS

VSD, Type 4 (Muscular), **Multiple**
VSD, Type 4 (Muscular), **Multiple—"Swiss-Cheese"**
VSD, Type 4 (Muscular), **Inlet (Posterior)**
VSD, Type 4 (Muscular), **Trabecular**
VSD, Type 4 (Muscular), **Outlet**
VSD, Type 4 (Muscular), **Confluent**

VSD, Type: Gerbode type (LV-RA communication), NOS

VSD Hierarchy Level 3 Definitions

VSD, Type 1 (Subarterial) (Supracristal) (Conal septal defect) (Infundibular)

VSD, TYPE 1 (SUBARTERIAL) (SUPRACRISTAL) (CONAL SEPTAL DEFECT) (INFUNDIBULAR), NOS: A subarterial VSD not further described.

VSD, TYPE 1 (SUBARTERIAL) (SUPRACRISTAL) (CONAL SEPTAL DEFECT) (INFUNDIBULAR), CONAL MUSCULAR: A subarterial VSD completely surrounded by muscle. This VSD lies in the conal or infundibular septum with muscle between the VSD and the semilunar valves.

VSD, TYPE 1 (SUBARTERIAL) (SUPRACRISTAL) (CONAL SEPTAL DEFECT) (INFUNDIBULAR), JUXTAARTERIAL: A subarterial VSD that lies immediately beneath the semilunar valve(s) in the conal or outlet septum. This VSD is limited upstream by the semilunar valve(s), but is otherwise surrounded by muscle. Muscle does not separate the VSD from the semilunar valve(s).

VSD, Type 2 (Perimembranous), (Paramembranous), (Conoventricular)

VSD, TYPE 2 (PERIMEMBRANOUS), (PARAMEMBRANOUS), (CONOVENTRICULAR), NOS: A perimembranous VSD not further described.

> Note that many surgeons might utilize this choice as the term used to describe their most common type of VSD and consider further description into other hierarchical choices as irrelevant. The advantage of this hierarchical nomenclature system is that these surgeons can stop at this level and still share data with other surgeons who choose to code in more detail. Clearly, many surgeons might question the relevance of this additional detail, but other programs, especially some in Europe, will want to code using the terms trabecular, outlet, and confluent as defined below.

VSD, TYPE 2 (PERIMEMBRANOUS), (PARAMEMBRANOUS), (CONOVENTRICULAR), INLET: A type 2 VSD which extends towards the inlet portion of the septum.

VSD, TYPE 2 (PERIMEMBRANOUS), (PARAMEMBRANOUS), (CONOVENTRICULAR), TRABECULAR: A type 2 VSD which extends towards the trabecular or apical septum.

VSD, TYPE 2 (PERIMEMBRANOUS), (PARAMEMBRANOUS), (CONOVENTRICULAR), OUTLET: A type 2 VSD which extends toward the outlet portion of the septum.

VSD, TYPE 2 (PERIMEMBRANOUS), (PARAMEMBRANOUS), (CONOVENTRICULAR), CONFLUENT: A type 2 VSD that extends towards multiple parts of the septum, including the inlet, trabecular, and outlet portions.

VSD, Type 3 (Inlet) (AV Canal type)

VSD, TYPE 3 (INLET) (AV CANAL TYPE), NOS: An inlet VSD not further described.

VSD, TYPE 3 (INLET) (AV CANAL TYPE), ASSOCIATED WITH AV CANAL DEFECT: An inlet VSD that is associated with an AV canal defect.

VSD, TYPE 3 (INLET) (AV CANAL TYPE), NOT ASSOCIATED WITH AV CANAL DEFECT: An inlet VSD that is not associated with an AV canal defect.

VSD, Type 4 (Muscular)

VSD, TYPE 4 (MUSCULAR), NOS: A muscular VSD not further described.

VSD, TYPE 4 (MUSCULAR), MULTIPLE: More than one muscular VSD exists. Each individual muscular VSD may then be coded separately to specify the individual muscular VSD types.

VSD, TYPE 4 (MUSCULAR), MULTIPLE—"SWISS-CHEESE": More than three muscular VSDs exist. A variety of definitions have been used to define this entity [10–12] including uncountable multiple VSDs [12]. Nevertheless, for the purpose of this database, this term can be utilized if four or more muscular VSDs exist, as defined by Serraf and colleagues [10].

VSD, TYPE 4 (MUSCULAR), INLET: (SYNONYM: POSTERIOR): A muscular VSD in the inlet portion of the ventricular septum. This term is used to describe an AV canal type VSD with muscle between the defect and the AV valve(s).

VSD, TYPE 4 (MUSCULAR), TRABECULAR: A muscular VSD in the trabecular portion of the septum.

VSD, TYPE 4 (MUSCULAR), OUTLET: A muscular VSD extending towards the outlet portion of the septum.

VSD, TYPE 4 (MUSCULAR), CONFLUENT: A muscular VSD that extends towards multiple parts of the septum, including the inlet, trabecular, and outlet portions.

VSD Hierarchy Level 4

VSD, NOS
VSD, Multiple, NOS
VSD, Multiple, 2 VSD
VSD, Multiple, 3 VSD
VSD, Multiple, 4 VSD
VSD, Multiple, 5 VSD
VSD, Multiple, 6 VSD
VSD, Multiple, More than 6 VSD
VSD, Type 1 (Subarterial) (Supracristal) (Conal septal defect) (Infundibular), NOS
VSD, Type 1 (Subarterial) (Supracristal) (Conal septal defect) (Infundibular) Conal Muscular
VSD, Type 1 (Subarterial) (Supracristal) (Conal septal defect) (Infundibular), Juxtaarterial, NOS

VSD, Type 1 (Subarterial) (Supracristal) (Conal septal defect) (Infundibular), Juxtaarterial, **Doubly committed**

VSD, Type 2 (Perimembranous) (Paramembranous) (Conoventricular), NOS
VSD, Type 2 (Perimembranous) (Paramembranous) (Conoventricular), Inlet
VSD, Type 2 (Perimembranous) (Paramembranous) (Conoventricular), Trabecular
VSD, Type 2 (Perimembranous) (Paramembranous) (Conoventricular), Outlet, NOS

VSD, Type 2 (Perimembranous) (Paramembranous) (Conoventricular), Outlet, **Conal septal malalignment**

VSD, Type 2 (Perimembranous) (Paramembranous) (Conoventricular), Confluent
VSD, Type 3 (Inlet) (AV canal type), NOS
VSD, Type 3 (Inlet) (AV canal type), Associated with AV canal defect
VSD, Type 3 (Inlet) (AV canal type), Not associated with AV canal defect
VSD, Type 4 (Muscular), NOS
VSD, Type 4 (Muscular), Multiple
VSD, Type 4 (Muscular), Multiple—"Swiss-Cheese"
VSD, Type 4 (Muscular), Inlet (Posterior)
VSD, Type 4 (Muscular), Trabecular, NOS

VSD, Type 4 (Muscular), Trabecular, **Anterior**
VSD, Type 4 (Muscular), Trabecular, **Apical**
VSD, Type 4 (Muscular), Trabecular, **Midventricular**

VSD, Type 4 (Muscular), Outlet
VSD, Type 4 (Muscular), Confluent
VSD, Type: Gerbode type (LV-RA communication), NOS

VSD Hierarchy Level 4 Definitions

VSD, TYPE 1 (SUBARTERIAL) (SUPRACRISTAL) (CONAL SEPTAL DEFECT) (INFUNDIBULAR), JUXTAARTERIAL:

Type 4 (Muscular), Trabecular subgroup; and consequently, the trabecular septum and this subgroup have been analyzed in more detail, leading to the following subdivisions [10, 13]: NOS, anterior, apical, and midventricular.

VSD, TYPE 4 (MUSCULAR), TRABECULAR, ANTERIOR: A muscular trabecular VSD anterior to the septal or moderator band, in the high trabecular septum.

VSD, TYPE 4 (MUSCULAR), TRABECULAR, APICAL: A muscular trabecular VSD near the cardiac apex, in the low trabecular septum.

VSD, TYPE 4 (MUSCULAR), TRABECULAR, MIDVENTRICULAR: A muscular trabecular VSD in the midseptum just inferior to the septal or moderator band, in the midtrabecular septum.

VSD Hierarchy Level 5

VSD, NOS
VSD, Multiple, NOS
VSD, Multiple, 2 VSD
VSD, Multiple, 3 VSD
VSD, Multiple, 4 VSD
VSD, Multiple, 5 VSD
VSD, Multiple, 6 VSD
VSD, Multiple, More than 6 VSD
VSD, Type 1 (Subarterial) (Supracristal) (Conal septal defect) (Infundibular), NOS
VSD, Type 1 (Subarterial) (Supracristal) (Conal septal defect) (Infundibular), Conal muscular
VSD, Type 1 (Subarterial) (Supracristal) (Conal septal defect), (Infundibular), Juxtaarterial, NOS
VSD, Type 1 (Subarterial) (Supracristal) (Conal septal defect), (Infundibular), Juxtaarterial, Doubly committed
VSD, Type 2 (Perimembranous) (Paramembranous) (Conoventricular), NOS
VSD, Type 2 (Perimembranous) (Paramembranous) (Conoventricular), Inlet
VSD, Type 2 (Perimembranous) (Paramembranous) (Conoventricular), Trabecular
VSD, Type 2 (Perimembranous) (Paramembranous) (Conoventricular), Outlet, NOS
VSD, Type 2 (Perimembranous) (Paramembranous) (Conoventricular), Outlet, Conal septal malalignment, NOS

VSD, Type 2 (Perimembranous) (Paramembranous) (Conoventricular), Outlet, Conal septal malalignment, **TOF type**
″VSD, Type 2 (Perimembranous) (Paramembranous) (Conoventricular), Outlet, Conal septal malalignment, **IAA type**

VSD, Type 2 (Perimembranous) (Paramembranous) (Conoventricular), Confluent
VSD, Type 3 (Inlet) (AV canal type), NOS
VSD, Type 3 (Inlet) (AV canal type), Associated with AV canal defect

VSD, TYPE 2 (PERIMEMBRANOUS) (PARAMEMBRANOUS) (CONOVENTRICULAR), OUTLET, CONAL SEPTAL MALALIGNMENT, TOF TYPE: A type 2 VSD with anterior malalignment of the infundibular septum.

VSD, TYPE 2 (PERIMEMBRANOUS) (PARAMEMBRANOUS) (CONOVENTRICULAR), OUTLET, CONAL SEPTAL MALALIGNMENT, IAA TYPE: A type 2 VSD with posterior malalignment of the infundibular septum.

Additional Modifiers for VSD Hierarchy Level 1

VSD, **Persistent (Postoperative intentional)**
VSD, **Previously created (Iatrogenic)**
VSD, **Postinfarct**
VSD, **Residual**
VSD, **Restrictive**

Additional Modifiers for VSD: Hierarchy Level 1 Definitions

VSD, PERSISTENT (POSTOPERATIVE INTENTIONAL): Any VSD that was intentionally left open at a previous operation such as in the case of Tetralogy with pulmonary atresia and severely hypoplastic pulmonary arteries (PA) where RV to PA continuity was established, but the VSD was left alone.

VSD, PREVIOUSLY CREATED (IATROGENIC): Any VSD that was surgically created at a previous operation or intervention.

VSD, POSTINFARCT: Any VSD caused by a myocardial infarction.

VSD, RESIDUAL: Any VSD that had attempted closure or was missed at the time of prior operation or intervention.

VSD, RESTRICTIVE: Any VSD that is small enough to restrict flow across it such that a pressure gradient exists between the two sides of the VSD.

Additional Modifiers for VSD: Hierarchy Level 2

VSD, Persistent (Postoperative intentional)
VSD, Previously created (Iatrogenic), NOS

VSD, Previously created (Iatrogenic), **Inadvertently created**
VSD, Previously created (Iatrogenic), **Intentionally created**

VSD, Postinfarct
VSD, Residual, NOS

VSD, Residual, **After surgery**
VSD, Residual, **After occlusion device**

VSD, Restrictive

Additional Modifiers for VSD: Hierarchy Level 3

VSD, Persistent (Postoperative intentional)
VSD, Previously created (Iatrogenic), NOS
VSD, Previously created (Iatrogenic), Inadvertently created
VSD, Previously created (Iatrogenic), Intentionally created
VSD, Postinfarct
VSD, Residual, NOS
VSD, Residual, After surgery, NOS

VSD, Residual, After surgery, **Qp:Qs < 1.5:1**
VSD, Residual, After surgery, **Qp:Qs ≥ 1.5:1**

VSD, Residual, After occlusion device, NOS

VSD, Residual, After occlusion device, **Qp:Qs < 1.5:1**
VSD, Residual, After occlusion device, **Qp:Qs ≥ 1.5:1**

VSD, Restrictive

III. Nomenclature for VSD Treatment Options

VSD Treatment Hierarchy Level 1

VSD creation
VSD enlargement
Ventricular septal fenestration
VSD repair
VSD multiple repair
PA banding

VSD Treatment Hierarchy Level 1 Definitions

VSD CREATION: Surgical creation of a VSD

VSD Treatment Hierarchy Level 2

VSD creation
VSD enlargement
Ventricular septal fenestration
VSD repair, NOS

VSD repair, **Device**
VSD repair, **Patch**
VSD repair, **Primary closure**
VSD repair, **Takedown**

VSD multiple repair
PA banding

VSD Treatment Hierarchy Level 3

VSD creation
VSD enlargement
Ventricular septal fenestration
VSD repair, NOS
VSD repair, Device, NOS

VSD repair, Device, **Type 1 (Subarterial) (Supracristal) (Conal septal defect) (Infundibular)**
VSD repair, Device, **Type 2 (Perimembranous) (Paramembranous) (Conoventricular)**
VSD repair, Device, **Type 3 (Inlet) (AV canal type)**
VSD repair, Device, **Type 4 (Muscular)**
VSD repair, Device, **Type: Gerbode (LV-RA communication)**

VSD repair, Patch, NOS

VSD repair, Patch, **Type 1 (Subarterial) (Supracristal) (Conal septal defect)**
VSD repair, Patch, **Type 2 (Perimembranous) (Paramembranous) (Conoventricular)**
VSD repair, Patch, **Type 3 (Inlet) (AV canal type)**
VSD repair, Patch, **Type 4 (Muscular)**
VSD repair, Patch, **Type: Gerbode (LV-RA communication**

VSD repair, Primary closure, NOS

VSD repair, Primary closure, **Type 1 (Subarterial) (Supracristal) (Conal septal defect) (Infundibular)**
VSD repair, Primary closure, **Type 2 (Perimembranous) (Paramembranous) (Conoventricular)**
VSD repair, Primary closure, **Type 3 (Inlet) (AV canal type)**
VSD repair, Primary closure, **Type 4 (Muscular)**
VSD repair, Primary closure, **Type: Gerbode (LV-RA communication**

VSD repair, Takedown
VSD multiple repair
PA banding

Additional Comments Regarding Therapeutics

In addition to the above basic treatment options for VSD, several other therapeutic issues must be addressed and coded in other areas of the database. First, separate areas of coding must cover palliative treatment of VSD (PA banding and debanding). Second, a separate part of the database must allow for coding for incisions for this and all other diagnoses (median sternotomy, submammary incision, right thoractomy, left thoracotomy, minimally invasive incisions, including partial sternotomy, parasternal incision, mini-thoracotomy, etc). Third, a separate part of the database must allow for coding of cardiac incisions for this and all other diagnoses (aortomy, pulmonary arteriotomy, right atriotomy, right ventriculotomy, left ventriculotomy, etc). Finally, a separate module of the database must permit coding of **patch materials** (Dacron, Gore-Tex [W.L. Gore & Associates, Flagstaff, AZ], bovine pericardium, autologous pericardium, gluteraldehyde fixated autologous pericardium, etc).

IV. Diagnosis and Procedure Short Lists

Diagnosis Short List

VSD single
VSD multiple

Procedure Short List

VSD repair, Patch
VSD repair, Primary closure
VSD repair, Device
VSD multiple repair
VSD creation/enlargement
Ventricular septal fenestration
PA banding

V: Potential Diagnostic Related Risk Factors

In addition to the common data fields utilized in the minimal data set and comprehensive data set applicable to all lesions, specific data fields to be tracked for VSD include the following data fields.

Preoperative aortic prolapse and postoperative progression of aortic insufficiency in cases of subarterial VSD [VSD, Type 1 (Subarterial) (Supracristal) (Conal septal defect) [9].
Preoperative aortic insufficiency and postoperative progression of aortic insufficiency in cases of subarterial VSD [VSD, Type 1 (Subarterial) (Supracristal) (Conal septal defect)] [9].
Specific postoperative complications of VSD to be studied include:
  Heart block
  Delayed sternal closure
  Need for mechanical circulatory support
  Residual VSD
    Qp:Qs $\geq$ 1.5:1
    Qp:Qs $<$ 1.5:1
  Reoperative for residual VSD

Lesion specific risk factors include: VSD, Multiple.

VI. Database Studies and Outcome Analysis

VSD: Inclusion Criteria and Allowable Concomitant Diagnoses

A case is included for VSD analysis if the primary diagnosis is VSD and concomitant cardiac diagnoses are none, left superior vena cava, patent ductus arteriosus, atrial septal defect, or any combination of these.

If no VSD subtype is given, the VSD will be classified as VSD, NOS.

Outcome Tables

VSD SURGERY TYPE (BY YEAR): This table will show the number and percentage of each major VSD type (according to VSD hierarchy level 2) for each year. (If no VSD subtype is given, the VSD will be classified as VSD, NOS). (All tables below will break down the data for each given year of data collection and also will provide the total data of the cumulative experience).

VSD METHOD OF DIAGNOSIS FOR EACH VSD TYPE (BY YEAR): This table will show the method of diagnosis for each major VSD type for each year.

VSD AGE [YEARS] AT OPERATION FOR EACH VSD TYPE (BY YEAR): This table will show the distribution of age at operation for each major VSD type for each year.

VSD GENDER DISTRIBUTION FOR EACH VSD TYPE (BY YEAR): This table will show the gender for each major VSD type for each year.

VSD—NUMBER AND PERCENTAGE WITH PRIOR PA BAND FOR EACH VSD TYPE (BY YEAR): This table will show the number and percentage of each major VSD type treated with prior PA band for each year.

VSD FEATURES OF REPAIR—CARDIOPULMONARY BYPASS (BY YEAR): This table will show the number and percentage of each major VSD type treated with cardiopulmonary bypass for each year.

VSD FEATURES OF REPAIR—AORTIC CROSS-CLAMP (BY YEAR): This table will show the number and percentage of each major VSD type treated with aortic cross-clamping for each year.

VSD FEATURES OF REPAIR—INDUCED FIBRILLATION (BY YEAR): This table will show the number and percentage of each major VSD type treated with induced fibrillation for each year.

VSD FEATURES OF REPAIR—PERCENT OF PATIENTS HAVING DEEP HYPOTHERMIA AND CIRCULATORY ARREST (BY YEAR): This table will show the number and percentage of each major VSD type treated with circulatory arrest for each year.

VSD FEATURES OF REPAIR—PERCENT OF PATIENTS LESS THAN 6 MONTHS HAVING DEEP HYPOTHERMIA AND CIRCULATORY ARREST (BY YEAR): For patients less than 6 months, this table will show the number and percentage of each major VSD type treated with circulatory arrest for each year.

VSD FEATURES OF REPAIR—PERCENT OF PATIENTS GREATER THAN OR EQUAL TO 6 MONTHS HAVING DEEP HYPOTHERMIA AND CIRCULATORY ARREST (BY YEAR): For patients greater than or equal to 6 months, this table will show the number and percentage of each major VSD type treated with circulatory arrest for each year.

VSD FEATURES OF REPAIR—MYOCARDIAL PRESERVATION [CARDIOPLEGIA TYPE] (BY YEAR): For patients treated with cross-clamping, this table will show the number and percentage of each major VSD type treated with various cardioplegia types including blood, crystalloid, substrate enriched, and other.

VSD FEATURES OF REPAIR—INCISION TYPE (BY YEAR): This table will show the number and percentage of each major incision type (median sternotomy, submammary incision, right thoracotomy, left thoracotomy, minimally invasive incisions, including partial sternotomy, parasternal incision, mini-thoracotomy, etc) for each major VSD type for each year.

VSD FEATURES OF REPAIR—CARDIAC INCISION TYPE (BY YEAR): This table will show the number and percentage of each major cardiac incision type (aortotomy, pulmonary arteriotomy, right atriotomy, right ventriculotomy, left ventriculotomy, etc) for each major VSD type for each year.

VSD FEATURES OF REPAIR—CLOSURE TECHNIQUE (BY YEAR): This table will show the number and percentage of primary (suture), patch, and device closure for each major VSD type for each year.

VSD COMPLICATION INCIDENCE (INCLUDING OPERATIVE DEATH) (BY YEAR): This table will show the number and percentage of operative deaths and complications (both transient and permanent, for each major organ system, including cardiac, pulmonary, renal, infectious, and neurologic) for each major VSD type for each year.

VSD COMPLICATION INCIDENCE (INCLUDING OPERATIVE DEATH) PATIENTS LESS THAN 6 MONTHS OF AGE (BY YEAR): For patients less than 6 months, this table will show the number and percentage of operative deaths and complications (both transient and permanent, for each major organ system, including cardiac, pulmonary, renal, infectious, and neurologic) for each major VSD type for each year.

VSD COMPLICATION INCIDENCE (INCLUDING OPERATIVE DEATH) PATIENTS GREATER THAN 6 MONTHS OF AGE (BY YEAR): For patients greater than 6 months, this table will show the number and percentage of operative deaths and complications (both transient and permanent, for each major organ system, including cardiac, pulmonary, renal, infectious, and neurologic) for each major VSD type for each year.

VSD PREOPERATIVE LENGTH OF VENTILATION (HOURS) (BY YEAR): This table will show the preoperative length of ventilation for each major VSD type for each year.

VSD POSTOPERATIVE LENGTH OF VENTILATION (HOURS) (BY YEAR): This table will show the postoperative length of ventilation for each major VSD type for each year.

VSD TOTAL LENGTH OF VENTILATION (HOURS) (BY YEAR): This table will show the total length of ventilation for each major VSD type for each year.

VSD PREOPERATIVE LENGTH OF STAY (DAYS) (BY YEAR): This table will show the preoperative length of stay for each major VSD type for each year.

VSD SAME DAY SURGERY (BY YEAR): This table will show the number and percentage of day of surgery admissions for each major VSD type for each year.

VSD POSTOPERATIVE LENGTH OF STAY (DAYS) (BY YEAR): This table will show the postoperative length of stay for each major VSD type for each year.

VSD TOTAL LENGTH OF STAY (DAYS) (BY YEAR): This table will show the total length of stay for each major VSD type for each year.

VSD PREOPERATIVE LENGTH OF STAY (DAYS) BY PATIENT AGE (BY YEAR): This table will show the preoperative length of stay for each major VSD type for each year, comparing patients less than 6 months to those greater than or equal to 6 months.

VSD SAME DAY SURGERY BY PATIENT AGE (BY YEAR): This table will show the number and percentage of day of surgery admissions for each major VSD type for each year, comparing patients less than 6 months to those greater than or equal to 6 months.

VSD POSTOPERATIVE LENGTH OF STAY (DAYS) BY PATIENT AGE (BY YEAR): This table will show the postoperative length of stay for each major VSD type for each year, comparing patients less than 6 months to those greater than or equal to 6 months.

VSD TOTAL LENGTH OF STAY (DAYS) BY PATIENT AGE (BY YEAR): This table will show the total length of stay for each major VSD type for each year, comparing patients less than 6 months to those greater than or equal to 6 months.

KAPLAN-MEIER CURVES: Kaplan-Meier survival curves should be generated for each major VSD type for each year, comparing the total VSD cohort to patients less than 6 months to those greater than or equal to 6 months.

VSD COMPLICATION INCIDENCE (INCLUDING OPERATIVE DEATH) VERSUS PREOPERATIVE VENTILATION (BY YEAR): This table will compare the number and percentage of operative deaths and complications (both transient and permanent, for each major organ system, including cardiac, pulmonary, renal, infectious, and neurologic), in patients treated with and without preoperative ventilation, for each major VSD type for each year.

VSD COMPLICATION INCIDENCE (INCLUDING OPERATIVE DEATH) VERSUS DEEP HYPOTHERMIA AND CIRCULATORY ARREST (BY YEAR): This table will compare the number and percentage of operative deaths and complications (both transient and permanent, for each major organ system, including cardiac, pulmonary, renal, infectious, and neurologic), in patients treated with and without circulatory arrest, for each major VSD type for each year.

VSD COMPLICATION INCIDENCE (INCLUDING OPERATIVE DEATH) VERSUS MYOCARDIAL PRESERVATION [CARDIOPLEGIA TYPE] (BY YEAR): This table will compare the number and percentage of operative deaths and complications (both transient and permanent, for each major organ system [cardiac, pulmonary, renal, infectious, and neurologic), in patients treated with various cardioplegia types including blood, crystalloid, substrate enriched, and other, for each major VSD type for each year.

VSD COMPLICATION INCIDENCE (INCLUDING OPERATIVE DEATH) VERSUS INCISION TYPE (BY YEAR): This table will compare the number and percentage of operative deaths and complications (both transient and permanent, for each major organ system, including cardiac, pulmonary, renal, infectious, and neurologic), in patients treated with each major incision type (median sternotomy, submammary incision, right thoracotomy, left thoracotomy, minimally invasive incisions, including partial sternotomy, parasternal incision, minithoracotomy, etc), for each major VSD type for each year.

VSD COMPLICATION INCIDENCE (INCLUDING OPERATIVE DEATH) VERSUS CARDIAC INCISION TYPE (BY YEAR): This table will compare the number and percentage of operative deaths and complications (both transient and permanent, for each major organ system, including cardiac, pulmonary, renal, infectious, and neurologic), in patients treated with each major cardiac incision type (aortotomy, pulmonary arteriotomy, right atriotomy, right ventriculotomy, left ventriculotomy, etc), for each major VSD type for each year.

VSD COMPLICATION INCIDENCE (INCLUDING OPERATIVE DEATH) VERSUS CLOSURE TECHNIQUE (BY YEAR): This table will compare the number and percentage of operative deaths and complications (both transient and permanent, for each major organ system, including cardiac, pulmonary, renal, infectious, and neurologic), in patients treated with primary (suture), patch, and device closure, for each major VSD type for each year.

VSD POSTOPERATIVE LENGTH OF VENTILATION (HOURS) VERSUS PREOPERATIVE VENTILATION (BY YEAR): This table will compare the postoperative length of ventilation, in patients treated with and without

preoperative ventilation, for each major VSD type for each year.

VSD POSTOPERATIVE LENGTH OF VENTILATION (HOURS) VERSUS DEEP HYPOTHERMIA AND CIRCULATORY ARREST (BY YEAR): This table will comare the postoperative length of ventilation, in patients treated with and without circulatory arrest, for each major VSD type for each year.

VSD POSTOPERATIVE LENGTH OF VENTILATION (HOURS) VERSUS MYOCARDIAL PRESERVATION [CARDIOPLEGIA TYPE] (BY YEAR): This table will compare the postoperative length of ventilation, in patients treated with various cardioplegia types including blood, crystalloid, substrate enriched, and other, for each major VSD type for each year.

VSD POSTOPERATIVE LENGTH OF VENTILATION (HOURS) VERSUS INCISION TYPE (BY YEAR): This table will compare the postoperative length of ventilation, in patients treated with each major incision type (median sternotomy, submammary incision, right thoracotomy, left thoracotomy, minimally invasive incision, including partial sternotomy, parasternal incision, minithoracotomy, etc), for each major VSD type for each year.

VSD POSTOPERATIVE LENGTH OF VENTILATION (HOURS) VERSUS CARDIAC INCISION TYPE (BY YEAR): This table will compare the postoperative length of ventilation, in patients treated with each major cardiac incision type (aortotomy, pulmonary arteriotomy, right atriotomy, right ventriculotomy, left ventriculotomy, etc), for each major VSD type for each year.

VSD POSTOPERATIVE LENGTH OF VENTILATION (HOURS) VERSUS CLOSURE TECHNIQUE (BY YEAR): This table will compare the postoperative length of ventilation, in patients treated with primary (suture), patch, and device closure, for each major VSD type for each year.

VSD POSTOPERATIVE LENGTH OF STAY (DAYS) VERSUS PREOPERATIVE VENTILATION (BY YEAR): This table will compare the postoperative length of stay, in patients treated with and without preoperative ventilation, for each major VSD type for each year.

VSD POSTOPERATIVE LENGTH OF STAY (DAYS) VERSUS DEEP HYPOTHERMIA AND CIRCULATORY ARREST (BY YEAR): This table will compare the postoperative length of stay, in patients treated with and without circulatory arrest, for each major VSD type for each year.

VSD POSTOPERATIVE LENGTH OF STAY (DAYS) VERSUS MYOCARDIAL PRESERVATION [CARDIOPLEGIA TYPE] (BY YEAR): This table will compare the postoperative length of stay, in patients treated with various cardioplegia types including blood, crystalloid, substrate enriched, and other, for each major VSD type for each year.

VSD POSTOPERATIVE LENGTH OF STAY (DAYS) VERSUS INCISION TYPE (BY YEAR): This table will compare the postoperative length of stay, in patients treated with each major incision type (median sternotomy, submammary incision, right thoracotomy, left thoracotomy, minimally invasive incision, including partial sternotomy, parasternal incision, minithoracotomy, etc), for each major VSD type for each year.

VSD POSTOPERATIVE LENGTH OF STAY (DAYS) VERSUS CARDIAC INCISION TYPE (BY YEAR): This table will compare the postoperative length of stay, in patients treated with each major cardiac incision type (aortotomy, pulmonary arteriotomy, right atriotomy, right ventriculotomy, left ventriculotomy, etc), for each major VSD type for each year.

VSD POSTOPERATIVE LENGTH OF STAY (DAYS) VERSUS CLOSURE TECHNIQUE (BY YEAR): This table will compare the postoperative length of stay, in patients treated with primary (suture), patch, and device closure, for each major VSD type for each year.

Figures 1 through 7 were prepared by Jeffrey A. White, MS.

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