Technical Report

ISO/TR 18965

First edition
2025-02

Medical devices — Examples of the application of the risk management process to cardiac valve replacement and repair systems

Dispositifs médicaux — Exemples d'application du processus de gestion des risques aux systèmes de remplacement et de réparation des valves cardiaques

Reference number
ISO/TR 18965:2025(en)

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Published in Switzerland

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 150, *Implants for surgery*, Subcommittee SC 2, *Cardiovascular implants and extracorporeal systems.*

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Risk management is the underlying foundation of the product development process and should be considered throughout all phases of the product development cycle. This document provides guidance to assist manufacturers on the application of the risk management process, as described in ISO 13485 and ISO 14971, to cardiac valve replacement and repair systems. Figure 1 demonstrates the relationship between the risk and device standards as well as the applicable Technical Reports that support the risk management process.

Medical devices — Examples of the application of the risk management process to cardiac valve replacement and repair systems

1 Scope

This document illustrates the implementation of the risk management process to the total product life cycle of cardiac valve replacement and repair systems. It provides specific examples of how risk management requirements and concepts can be applied to new or modified cardiac valve replacement and repair systems. The informative examples included herein are not exhaustive.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 5840-2, *Cardiovascular implants — Cardiac valve prostheses — Part 2: Surgically implanted heart valve substitutes*

ISO 5840-3, *Cardiovascular implants — Cardiac valve prostheses — Part 3: Heart valve substitutes implanted by transcatheter techniques*

ISO 5910, *Cardiovascular implants and extracorporeal systems — Cardiac valve repair devices*

ISO 14971, *Medical devices — Application of risk management to medical devices*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5840-2, ISO 5840-3, ISO 5910 and ISO 14971 apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

NOTE The defined terms in ISO 5840-2, ISO 5840-3, ISO 5910 and ISO 14971 are derived as much as possible from ISO/IEC Guide 63, which was developed specifically for the medical device sector.

4 General risk management requirements

Decisions and actions, based on the information collected and analysed by application of this document, are described in other standards, such as ISO 13485, ISO 14971 and ISO/TR 24971, and are therefore not included in this document. The manufacturer may be required to perform other risk management activities to fulfil applicable regulatory requirements ISO/IEC Guide 63, for medical devices that are not discussed in this document. While regulatory requirements are not described here, this document can be helpful for manufacturers in fulfilling those regulatory requirements. This document uses the definition of risk management from ISO 13485 and ISO 14971.

5 Risk analysis

5.1 Risk analysis process

The risk analysis process is defined in ISO 14971 and guidance for the application of ISO 14971 can be found in ISO/TR 24971. Risk analysis examples are provided in this document specific to cardiac valve replacement and repair systems. These examples are provided as an illustration of how to apply the risk management process to these devices and are not intended to be an exhaustive list.

Inputs to the risk analysis process are defined in ISO 14971 and ISO/TR 24971.

5.2 Identification of intended use

An example of the identification of the intended use of a Transcatheter Aortic Valve Replacement (TAVR) system of one particular design, procedure, and set of use cases is shown below:

— Device or system description: The TAVR system consisting of three primary components: a bioprosthesis consisting of bovine pericardial tissue mounted on a nitinol self-expanding frame, an 18 French catheter-based delivery system, and a disposable loading system. The TAVR is designed to replace the native aortic heart valve without open heart surgery and without concomitant surgical removal of the failed native valve. The self-expanding frame is manufactured from nitinol and is composed of different strut lengths and widths to accommodate expansion to its intended shape. The TAVR is indicated for the replacement of a defective native aortic heart valve by transluminal delivery. The TAVR is intended to be percutaneously inserted via the femoral artery access and deployed inside the existing failed native aortic valve.

— Intended medical indication: treatment of aortic stenosis.

— Patient population: adults with severe, symptomatic aortic stenosis.

— Intended implant site: within a native tricuspid aortic valve.

— Intended user: health care provider suitably trained to perform procedure.

— Use environment: hospital catheter lab or operating room.

— Operating principle: delivery of heart valve substitute via transcatheter delivery under fluoroscopic guidance; device can be recaptured and repositioned prior to final deployment.

5.3 Identification of reasonably foreseeable misuse

Reasonably foreseeable misuse is defined in ISO/TR 24971:2020, 5.2. Examples for cardiac valve replacement and repair systems are provided in Table 1:

Table 1 — Examples of reasonably foreseeable misuse

Device type	Misuse examples
Transcatheter heart valve	— excessive crimp times; — post-deployment dilation; — implanted outside the targeted annulus range (inappropriate oversizing or under sizing); — implanted outside the approved location.
Surgical heart valve	— bending of stent during implantation; — rotate non-rotatable mechanical valve after implantation; — surgical heart valve intentionally fractured to allow for valve-in-valve procedure.
Transcatheter repair	— gap in mitral leaflets larger than indicated gap size per device labelling. Implanted in patient with contraindicated mitral annular calcification (MAC).
Surgical repair	— shape of annuloplasty ring deformed during surgery.

5.4 Identification of system characteristics related to safety

Identification of system characteristics related to safety are defined in ISO/TR 24971:2020, 5.3 and Annex A.

Table 2 provides example evaluations to questions in ISO/TR 24971:2020, Annex A, and the associated hazards, hazardous situations, and harms derived from the answers. The list of answers and associated hazards, hazardous situations, and harms are not intended to be exhaustive.

Table 2 — Examples of answers to system characteristics related to safety and the resulting hazards, hazardous situations and harms

Question	Example answers	Hazards identified	Hazardous situations	Harm
A.2.31.4 Does the *medical device* have a control interface?	User fills the inflation device to specified volume through balloon inflation port.	User filled syringe	a) THV deployed with excessive volume leading to over-expansion; b) THV deployed with insufficient volume leading to under-expansion.	a) aortic annular rupture; b) para valvular leakage; c) migration.
	User loads the THV onto the delivery system using a crimping accessory	Frame edges	Insufficient crimping leads to protruding frame edges that contact vessel wall during tracking	Vessel perforation
	User releases implant by rotating implant release knob on implant catheter handle	Release knob detachment mechanism	Implant fails to detach from the delivery system leading to leaflet damage	regurgitation
	User de-airs transseptal sheath through designated flush ports on handle	Flush port	Unable to de-air through flush port, therefore air bubbles exit sheath tip during procedure	Myocardial infarction or stroke
	User rotates a cinching mechanism to contract the posts	Cinching mechanism	Unable to cinch appropriately, mis coaptation of the leaflets due to trapping leaflets behind suture	Regurgitation
A.2.4 What materials or components are utilized in the medical device or are used with, or are in contact with, the medical device?	Biological tissue for valve leaflets	Pericardial bovine leaflets packaged in glutaraldehyde	Insufficient rinse during device prep exposing patient to excess glutaraldehyde	Systemic inflammation
	Nitinol for implant	Presence of nickel in nitinol	Nickel leaching due to insufficient corrosion resistance	Systemic inflammation due to nickel toxicity
A.2.1 Is special intervention necessary in case of failure of the device?	Balloon inflation of stenotic leaflets on Surgical Replacement Valve	Balloon	Overinflation causing annular rupture	Annular rupture
			Cracking of calcium leads to calcium fragments	Emboli

5.5 Identification of hazards, hazardous situations and associated harms

Identification of hazards, hazardous situations, and associated harms are defined in ISO/TR 24971:2020, 5.4.

Table 3 provides examples of Hazards, Hazardous Situations, and Harms for cardiac valve replacement or repair systems. This list is not intended to be exhaustive and is only being provided for consideration by manufacturers. Consider specific design and use elements for each situation.