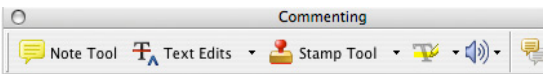
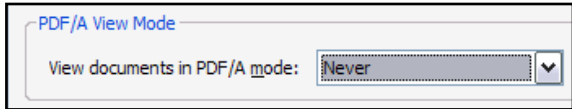
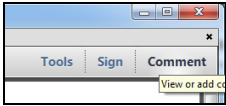
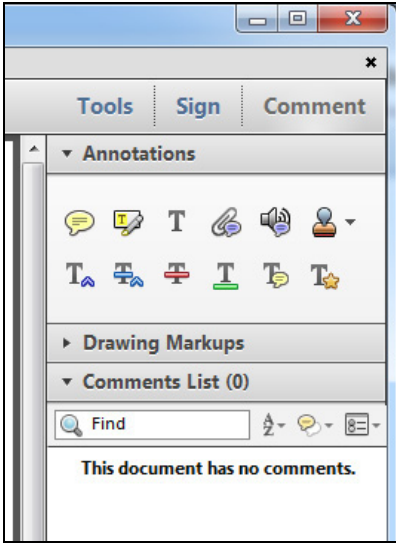













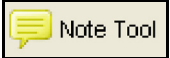

INSTRUCTIONS ON THE ANNOTATION OF PDF FILES


To view, print and annotate your content you will need Adobe Reader version 9 (or higher). This program is freely available for a whole series of platforms that include PC, Mac, and UNIX and can be downloaded from <http://get.adobe.com/reader/>. The exact system requirements are given at the Adobe site: <http://www.adobe.com/products/reader/tech-specs.html>.

Note: Please do NOT make direct edits to the PDF using the editing tools as doing so could lead us to overlook your desired changes. Rather, please request corrections by using the tools in the Comment pane to annotate the PDF and call out the changes you are requesting. If you opt to annotate the file with software other than Adobe Reader then please also highlight the appropriate place in the PDF file.

PDF ANNOTATIONS	
Adobe Reader version 9	Adobe Reader version X and XI
<p>When you open the PDF file using Adobe Reader, the Commenting tool bar should be displayed automatically; if not, click on 'Tools', select 'Comment & Markup', then click on 'Show Comment & Markup tool bar' (or 'Show Commenting bar' on the Mac). If these options are not available in your Adobe Reader menus then it is possible that your Adobe Acrobat version is lower than 9 or the PDF has not been prepared properly.</p>  <p>(Mac)</p> <p>PDF ANNOTATIONS (Adobe Reader version 9)</p> <p>The default for the Commenting tool bar is set to 'off' in version 9. To change this setting select 'Edit Preferences', then 'Documents' (at left under 'Categories'), then select the option 'Never' for 'PDF/A View Mode'.</p>  <p>(Changing the default setting, Adobe version 9)</p>	<p>To make annotations in the PDF file, open the PDF file using Adobe Reader XI, click on 'Comment'.</p> <p>If this option is not available in your Adobe Reader menus then it is possible that your Adobe Acrobat version is lower than XI or the PDF has not been prepared properly.</p>  <p>This opens a task pane and, below that, a list of all Comments in the text. These comments initially show all the changes made by our copyeditor to your file.</p> 

HOW TO...

Action	Adobe Reader version 9	Adobe Reader version X and XI
Insert text	Click the 'Text Edits' button  on the Commenting tool bar. Click to set the cursor location in the text and simply start typing. The text will appear in a commenting box. You may also cut-and-paste text from another file into the commenting box. Close the box by clicking on 'x' in the top right-hand corner.	Click the 'Insert Text' icon  on the Comment tool bar. Click to set the cursor location in the text and simply start typing. The text will appear in a commenting box. You may also cut-and-paste text from another file into the commenting box. Close the box by clicking on 'x'  in the top right-hand corner.
Replace text	Click the 'Text Edits' button  on the Commenting tool bar. To highlight the text to be replaced, click and drag the cursor over the text. Then simply type in the replacement text. The replacement text will appear in a commenting box. You may also cut-and-paste text from another file into this box. To replace formatted text (an equation for example) please Attach a file (see below).	Click the 'Replace (Ins)' icon  on the Comment tool bar. To highlight the text to be replaced, click and drag the cursor over the text. Then simply type in the replacement text. The replacement text will appear in a commenting box. You may also cut-and-paste text from another file into this box. To replace formatted text (an equation for example) please Attach a file (see below).
Remove text	Click the 'Text Edits' button  on the Commenting tool bar. Click and drag over the text to be deleted. Then press the delete button on your keyboard. The text to be deleted will then be struck through.	Click the 'Strikethrough (Del)' icon  on the Comment tool bar. Click and drag over the text to be deleted. Then press the delete button on your keyboard. The text to be deleted will then be struck through.
Highlight text/ make a comment	Click on the 'Highlight' button  on the Commenting tool bar. Click and drag over the text. To make a comment, double click on the highlighted text and simply start typing.	Click on the 'Highlight Text' icon  on the Comment tool bar. Click and drag over the text. To make a comment, double click on the highlighted text and simply start typing.
Attach a file	Click on the 'Attach a File' button  on the Commenting tool bar. Click on the figure, table or formatted text to be replaced. A window will automatically open allowing you to attach the file. To make a comment, go to 'General' in the 'Properties' window, and then 'Description'. A graphic will appear in the PDF file indicating the insertion of a file.	Click on the 'Attach File' icon  on the Comment tool bar. Click on the figure, table or formatted text to be replaced. A window will automatically open allowing you to attach the file. A graphic will appear indicating the insertion of a file.
Leave a note/ comment	Click on the 'Note Tool' button  on the Commenting tool bar. Click to set the location of the note on the document and simply start typing. <u>Do not use this feature to make text edits.</u>	Click on the 'Add Sticky Note' icon  on the Comment tool bar. Click to set the location of the note on the document and simply start typing. <u>Do not use this feature to make text edits.</u>

HOW TO...		
Action	Adobe Reader version 9	Adobe Reader version X and XI
Review	To review your changes, click on the 'Show' button  on the Commenting tool bar. Choose 'Show Comments List'. Navigate by clicking on a correction in the list. Alternatively, double click on any mark-up to open the commenting box.	Your changes will appear automatically in a list below the Comment tool bar. Navigate by clicking on a correction in the list. Alternatively, double click on any mark-up to open the commenting box.
Undo/delete change	To undo any changes made, use the right click button on your mouse (for PCs, Ctrl-Click for the Mac). Alternatively click on 'Edit' in the main Adobe menu and then 'Undo'. You can also delete edits using the right click (Ctrl-click on the Mac) and selecting 'Delete'.	To undo any changes made, use the right click button on your mouse (for PCs, Ctrl-Click for the Mac). Alternatively click on 'Edit' in the main Adobe menu and then 'Undo'. You can also delete edits using the right click (Ctrl-click on the Mac) and selecting 'Delete'.


SEND YOUR ANNOTATED PDF FILE BACK TO ELSEVIER

Save the annotations to your file and return as instructed by Elsevier. Before returning, please ensure you have answered any questions raised on the Query Form and that you have inserted all corrections: later inclusion of any subsequent corrections cannot be guaranteed.

FURTHER POINTS

- Any (grey) halftones (photographs, micrographs, etc.) are best viewed on screen, for which they are optimized, and your local printer may not be able to output the greys correctly.
- If the PDF files contain colour images, and if you do have a local colour printer available, then it will be likely that you will not be able to correctly reproduce the colours on it, as local variations can occur.
- If you print the PDF file attached, and notice some 'non-standard' output, please check if the problem is also present on screen. If the correct printer driver for your printer is not installed on your PC, the printed output will be distorted.

AUTHOR QUERY FORM

 ELSEVIER	Journal: ATS Article Number: 31554	Please e-mail your responses and any corrections to: E-mail: l.donovan@elsevier.com
--	---	--

Dear Author,

Please check your proof carefully and mark all corrections at the appropriate place in the proof (e.g., by using on-screen annotation in the PDF file) or compile them in a separate list. **It is crucial that you NOT make direct edits to the PDF using the editing tools as doing so could lead us to overlook your desired changes.** Note: if you opt to annotate the file with software other than Adobe Reader then please also highlight the appropriate place in the PDF file. To ensure fast publication of your paper please return your corrections within 48 hours.

For correction or revision of any artwork, please consult <http://www.elsevier.com/artworkinstructions>.

Any queries or remarks that have arisen during the processing of your manuscript are listed below and highlighted by flags in the proof.

Location in article	Query / Remark: Click on the Q link to find the query's location in text Please insert your reply or correction at the corresponding line in the proof
	If there are any drug dosages in your article, please verify them and indicate that you have done so by initialing this query
Q1	Reference 8 was a duplicate of Reference 2. Reference 8 was deleted from the Reference list, and original References 9-29 were renumbered as 8-28, both in the Reference list and the in-text citations throughout the article. In-text citations for original Reference 8 were replaced with Reference 2. Please review the Reference list and citations throughout the article to confirm that this is okay.
Q2	Please confirm that “high-efficiency particulate air” is the appropriate expansion for HEPA; adjust as needed.
Q3	Per journal style, “mortality” means the number of deaths per number of patients and is not used to mean a single death, or the probability of death. Please adjust as needed throughout the text.
Q4	References 4 and 5 do not appear to be listed in PubMed. Please check that the reference details are correct.

(continued on next page)

Q5

Please confirm that given names and surnames have been identified correctly and are presented in the desired order and please carefully verify the spelling of all authors' names.

Author affiliations will appear differently in the print and online versions of your paper. The PDF shows how the affiliations will present following journal style, whereas the searchable online version will present as follows in order to provide complete unabridged affiliations. Please check the accuracy of the affiliation(s) of each author and make changes as appropriate.

Richard L. Prager^a, Alejandro Murillo Berlioz^b, Gregory D. Trachiotis^b, Joseph B. Zwischenberger^c, and Robert M. Sade^d

^aDepartment of Cardiac Surgery, University of Michigan, Ann Arbor, Michigan

^bDivision of Cardiothoracic Surgery, Department of Surgery, George Washington University Medical Center, Veterans Affairs Medical Center, Washington, DC

^cDivision of Cardiothoracic Surgery, Department of Surgery, University of Kentucky, Lexington, Kentucky

^dDivision of Cardiothoracic Surgery, Department of Surgery, Institute of Human Values in Health Care, Medical University of South Carolina, Charleston, South Carolina

Please check this box or indicate
your approval if you have no
corrections to make to the PDF file

Thank you for your assistance.

Battling the Chimaera: How Much Disclosure of Rare Risks Is Necessary?

 **Richard L. Prager, MD,** **Alejandro Murillo Berlioz, MD,** **Gregory D. Trachiotis, MD,** **Joseph B. Zwischenberger, MD,** and **Robert M. Sade, MD**

Department of Cardiac Surgery, University of Michigan, Ann Arbor, Michigan; Division of Cardiothoracic Surgery, Department of Surgery, George Washington University Medical Center, Veterans Affairs Medical Center, Washington, DC; Division of Cardiothoracic Surgery, Department of Surgery, University of Kentucky, Lexington, Kentucky; and Division of Cardiothoracic Surgery, Department of Surgery, Institute of Human Values in Health Care, Medical University of South Carolina, Charleston, South Carolina

Introduction

Robert M. Sade, MD

A perennial problem in surgery is deciding how much information should be provided to a patient before an operation as part of the informed consent process. The amount should be enough to enable a reasonable person to make an informed decision regarding which of several options would be best for him or her. Too little information is disrespectful of the patient's autonomy, while too much can be confusing and may also be disrespectful of the patient's autonomy by undermining the patient's decision making. A recent widely publicized complication of cardiac operations provides an illuminating example of this problem.

The Case of the Resistant Chimaera

Mycobacterium chimaera infection has been associated with the LivaNova PLC Stöckert 3T heater-cooler system that is widely used in cardiac operations [1]. Infection in patients exposed to this device is rare, identified in 0.16% of such patients in one large series [2].

After the first report of this problem in 2015 and subsequent warnings from the Centers for Disease Control and Prevention (CDC) [3] and the Food and Drug Administration (FDA) [4], many institutions changed to a different heater-cooler system; the market was unprepared for this sudden demand, however, resulting in depleted supplies of alternative devices. Despite vigorous efforts to increase the supply, manufacturers have been unable to keep up with the demand.

The cardiac surgeons in Pegasus General Hospital (PGH) have been using the Stöckert 3T heater-cooler system in their open heart operations and are aware of the reports about this threat to their patients. They have ordered replacement devices, but the demand for alternative devices has been so great that PGH cannot obtain any for at least several months. The surgical team can further reduce the already very low risk of infection from the devices still in their possession by such maneuvers as directing the air flow emerging from the heater-cooler away from the patient.

The surgeons now face an ethical dilemma. They could continue using the heater-coolers they have and simply not tell patients about the problem, because the risk of *M chimaera* infection is so low that it need not be disclosed specifically; the potential for complications from the heart-lung machine, including a low risk of infections in general, would be included in the consent discussion. Alternatively, they could inform the patients about the problem with the heater-cooler, emphasizing the very low risk and giving patients the opportunity to have the operation or to be referred elsewhere. Dr Bellerophon is the head of the cardiac surgery program and also chairs the operating room committee, which sets policy for the operating room. Before he makes a decision, he consults two of his friends who have differing views on what he should do.

The debaters were assigned a position to take and were asked to articulate a strong argument in support of the assigned position. The statements contained in their essays should not be construed as representing the authors' personal opinions or beliefs.

Accepted for publication March 25, 2018.

Presented at the Sixty-fourth Annual Meeting of the Southern Thoracic Surgical Association, San Antonio, TX, Nov 8-11, 2017.

Address for correspondence to Dr Sade, 30 Courtenay St, BM 277, MSC 295, Charleston, SC 29425; email: sader@musc.edu.

Pro

Richard Prager, MD

Dr Bellerophon should institute a policy requiring that description of the specific risk of *M chimaera* infection be included in preoperative informed consent discussions.

Historical Background

As I considered the question concerning disclosure of rare risks before an operative procedure, noting the evolution of critical non-tuberculous mycobacterial infections in cardiac operations, I was first drawn to sorting out the reality of tuberculosis (TB), originally often called the white plague. Historically TB has been found in Egyptian mummies dating back to 3000 BCE. Hippocrates, thought to be the father of thoracic surgery for his clay pipe drainage of empyemas, called the disease “Phthisis” [5]. Heinrich Robert Koch isolated the bacterium in 1882, and TB became widespread in the 19th century, secondary to industrialization and urbanization. Sir Richard Evans, a Regius Professor of History at Cambridge, noted that as town and cities expanded and coal was used for heating, smoke and soot filled the air, so windows were closed and those with TB were easily able to spread the disease with respiratory droplets, especially in the setting of overcrowding, poverty, and poor nutrition [6].

Of interest, in the late 1800s an atypical mycobacterium was described and was found in sporadic case reports occurring in the first 50 years of the 1900s. In the 1980s a nodular bronchiectatic lung disease was found to be secondary to a non-TB mycobacterium (NTM); it was called Lady Windermere Syndrome, purportedly named after the title character in Oscar Wilde’s 1892 play, *Lady Windermere’s Fan*. Early in this century, Enrico Tortoli elevated a member of the *Mycobacterium avium* complex (MAC) to species rank: *Mycobacterium chimaera* sp. nov. This bacterium was noted to be found in lung disease in a small percentage of patients [7].

Infection With *M chimaera*

The modern story evolved from the publication in the *European Heart Journal* in 2015 of a study describing 10 patients, mean age 58 years, who were all immunocompetent and developed non-tuberculous bacterial infections, 8 with endocarditis and 2 with disseminated infections. At the time of publication 6 of the 10 had died. All the reporting centers had heater-cooler units inside their operating rooms [2].

The story continued with the report of 13 possible cases by the United Kingdom government, and in 2016 the CDC linked patient infections to potentially contaminated heater-cooler devices (HCDs), specifically

the LivaNova PLC Stöckert 3T Heater-Cooler System, and produced an interim practice guidance document [8].

The lay press stepped into this reality, including the *New York Times*, which in October 2016 led with a headline “Tainted Heart-Surgery Machine Said to Infect 12 in Pennsylvania.” Engineering review of these devices revealed several problems: questionable manufacturing procedures contaminated a number of machines with mycobacteria, and the device design allowed the possibility of leakage or spillage in this system.

With this in mind, the epidemiologic question centered on why *M chimaera*? It is critical to recognize that the *M chimaera* organism is resistant to commonly used disinfectants, it has adapted to survival at body temperature, and it forms a biofilm on metal surfaces—it essentially thrives in and spreads from treated tap water systems.

Furthermore, when these devices are in the operating rooms “smoke diffusion tests” make it clear that there is aerosolization throughout the operating room. With this in mind, cardiothoracic surgery professional societies throughout the world recommended following the CDC guidance, and institutions rethought the approach to heater-coolers, shifting them outside the operating room, changing to HCDs made by other companies if possible, following strict cleaning approaches, and even creating devices in which to place the heater-coolers with special high-efficiency particulate air filters. ⁰²

The Ethics of Informing Patients

Noting the high mortality in patients found to have these infections, and with the reality of the increasing knowledge of this, I believe it is not only appropriate but also a physician’s role to inform patients preoperatively of the possibility of a “rare risk complication,” which, if it occurs, has an extremely high risk of morbidity and mortality. ⁰³

In fact, I must admit that I cannot believe this is even a debate. The reason I say this is my belief that there are three or perhaps four facets to the original question: The first is the legal facet, the second the ethical, and the third the common sense, and, perhaps, a fourth the common sense in the era of Tweets, constant breaking news, and “alternative facts.”

Informed consent is rooted in old English law that is centuries old, and it essentially says each of us has the right to control who touches us and for what purpose. In medicine, which is complex, there is legally an added obligation to “inform” the patient before we proceed. Furthermore, in this setting there are those who discuss the “power differential” between patients and physicians; therefore, I believe we are obligated to provide patients

the best opportunity to understand what risks they face. The concept of self-determination is fundamental in Western society, and it is also clearly less paternalistic.

From the ethical perspective, patients trust us to do what is best, and rightfully so, because serving the interests of our patients is our paramount ethical obligation [9]. One of the most essential interests of our patients is their right to make medical decisions based on accurate understanding of the benefits, important risks, and options available when they must make health care decisions. Given these foundational rights and principles, it is clearly a breach of ethics to deliberately withhold information that is of gravity and importance.

Finally, we have the reality of common sense. To most thoughtful people the term "infection" is *not* synonymous with a 50% mortality, biofilm, and occurrences

years after exposure with availability of no straightforward treatment. This is not what our patients believe infection to be; merely mentioning the possibility of infection after the operation without specifically describing this particularly insidious and dangerous one is simply inadequate.

Expanding this concept, as health care providers, we recognize that we are the ones with sincere interest in our patients as people and that we care for them; this moves us into the subtext of common sense in the current era of Tweets and constant breaking news. Our patients put their *trust* in us as their surgeons, and the more honest we are the more we create a stronger bond between ourselves and our patients [10]. We should recognize that this is of critical importance to us and to our profession.

Con

Alejandro Murillo Berlioz, MD, Gregory D. Trachiotis, MD,
and Joseph B. Zwischenberger, MD

Dr Bellerophon should institute a policy stating that description of the specific risk of *M chimaera* infection need not be included in preoperative informed consent discussions.

M chimaera is a NTM that is part of the MAC; it is ubiquitous in aqueous environments and has been receiving increasing attention since February 2015 when it was linked to an outbreak of invasive disease in six postoperative cardiac surgical patients at the Zurich Heart Center. Transmission was described as aerosolization of water deposits. Initial investigations identified the LivaNova (formerly Sorin) HCD as the source of infection [8]. Latency between operation and manifest infection ranged from 1.5 to 3.6 years, and all except 1 patient showed echocardiographic evidence of endocarditis [11]. Since 2013, more than 100 cases of prosthetic valve endocarditis and disseminated infections due to *M chimaera* have been reported in the United States, Europe (Switzerland, Germany, United Kingdom, and the Netherlands), and Australia. This infectious outbreak, along with the help of the media, caused concern (which some would label hysteria) among our patients and colleagues. Despite that it was proven that all the drinking water in the identified intensive care unit was also contaminated by *M chimaera* (not only the Sorin 3TC HCDs), the attention has been focused on the relationship between the HCDs and the pathogen.

van Ingen and colleagues [12] performed whole-genome sequencing studies on 250 isolates of *M chimaera*. Whole-genome sequencing is considered the most powerful tool used to identify source of infection. They concluded that it is most probable that the

LivaNova HCDs involved in the infection outbreak were contaminated at their production site in Germany. Although it was found that there were cases of local contamination of the HCDs, the evidence did not support a strong link with patient infection [13]. This would confirm the relationship that Sax and colleagues [11] had established between *M chimaera* and the aqueous environments in their study published in 2015. Therefore, *M chimaera* is not exclusively found in the Sorin 3TC HCDs and may contaminate any other machine or device that uses a water supply, including dialysis units, ventilator machines, and other major care units in any hospital.

In August 2014, the manufacturer of 3TC HCDs ran testing and found contamination by *M chimaera* of their water supply and production lines. They implemented a device disinfection processes before shipment and added cleaning and disinfection procedures before the production line in September 2014. Modifications of the post-production process, updates in instructions for use, and regular relevant field safety notices were put into action that same year [14, 15]. Garvey and colleagues [16] worked with the LivaNova group in 2015 to develop an effective technique to disinfect the 3TC HCDs. The same group ran weekly tests in their LivaNova 3TC HCDs for more than a year after complying with the decontamination process based on LivaNova guidance. This involved replacing all the internal pipe work from the devices to remove any potential biofilm, close control of the HCDs water supply, and adding hydrogen peroxide and peracetic acid. Results of the weekly water tests from June 2015 to December 2016 revealed no evidence of *M chimaera* [17]. Having the knowledge that *M chimaera* is ubiquitous in aqueous

environments and having objectively proven that we have available and reproducible methods to decontaminate infected devices reduces the already low risk of infection by *M chimaera*.

CDC has estimated that in hospitals where at least one *M chimaera* infection has been documented, the risk of infection for patients varies between 1/100 and 1/1,000 [18]. Most importantly in the general cardiac population subject to cardiopulmonary bypass, the odds are still only approximately 1 in 7,000; roughly the risk of being struck by lightning in a lifetime. The most common isolated bacteria in patients who developed deep or superficial sternal wound infections after cardiac operation are coagulase-negative *Staphylococcus* and methicillin-sensitive *Staphylococcus aureus* [19]. The overall incidence of *Staphylococcus* species during open cardiac operation is roughly 3%. When comparing the risk of infection by *M chimaera* with other common risks that patients endure when undergoing cardiac operation, the risk of *M chimaera* is miniscule. In our unit (J.B.Z.), deep sternal wound infection for the past 5 years is less than 1%, and in isolated cases due to *Staphylococcus* species. Rigorous testing of our Sorin HCD found no evidence of *M chimaera*. Thus, the reality is that the risk of infection with *M chimaera* is vanishingly low. If disclosure of the risk of infection from other specific organisms that are known to cause a greater incidence of postoperative infections in patients undergoing cardiac operation with cardiopulmonary bypass is not necessary, the need for disclosing a specific risk of infection by *M chimaera* seems unfounded.

Regarding Ethics, Legal Issues, and Informed Consent

Concern after the media-magnified infectious outbreak of *M chimaera* from contaminated HCDs led us to examine the spectrum that exists between adequately informing and misinforming patients. Informed consent as a legal doctrine states that a person with age of majority and sound mind has the right to decide what is done to his or her body [20]. In accordance with this doctrine, a physician must disclose the necessary information for the patient to make an informed decision. This involves stating the risks and benefits of a procedure by using clear and understandable language. However, some information would only be stressful, confusing, and serve to undermine the risk-benefit discussion. Accordingly, the 1977 Minnesota Supreme Court case *Cornfeldt v Tongen* ruled that it is not necessary to disclose information to a patient if this is likely to cause psychological harm [21]. This argument is based on the physician's duty to benefit the patient and avoid causing harm (beneficence and non-maleficence). Cardiac operation with cardiopulmonary bypass imposes a considerable load of stress to the patients. There is a reasonable expectation that disclosing

organism-specific infection information is likely to cause these patients psychological harm. Unnecessary anxiety may negatively affect surgical outcomes. As such, current practice does not require disclosure of organism-specific infection; disclosing information about a very low incidence complication of known causality and that is effectively controlled should not be considered as acting on the principle of beneficence.

Approximately 500,000 coronary artery bypass graft operations are performed each year. Only one-fifth of these operations are performed off-pump [22]. The FDA believes that the benefit of open chest cardiac operation with cardiopulmonary bypass outweighs the risk of infection [23]. The contamination source for major outbreaks has been identified (production site), and maneuvers to reduce the patient risk of infection have been described (direct the airflow of the HCD away from the patient, increase water control in surgical areas, and replacement of initial tubing of the internal tubing of the HCD) [21].

After intense effort, the water supply of LivaNova's production site was identified as the source for the contamination of a specific batch of HCDs which led to the infectious outbreak. *M chimaera* is a ubiquitous organism that can be found in multiple water supply systems. *M chimaera* could potentially contaminate any HCD. Therefore, it is unfounded to state a link between 3TC HCDs and *M chimaera*, especially when effective contingency techniques have been implemented to eradicate the threat from the batch of HCDs that were contaminated.

The unpredictable nature and extremely low risk of infection suggests that we need not take extra steps to disclose this organism-specific infection on top of the risk for infections we already discuss during the informed-consent process. Likewise, the widespread publicity of *M chimaera* infections should consider that anyone researching open heart operation will easily find this information. Furthermore, most media outlets discussing the topic have suggested that patients bring up the bacteria issue themselves if they feel it needs to be addressed before the operation. This is not only because of the minuscule risk of infection, but also because the devices are critical for life-saving operations, and recalling them would do much more harm to the overall group of individuals undergoing heart operation compared with the small group who *may* have been infected.

The information disclosed while consenting for any cardiac surgical procedure is already vast and overwhelming to the patient. Disclosing the extremely low risk of infection with this ubiquitous organism would create further unnecessary stress to the patients. We already disclose that they have a risk of infection during the procedure; this should suffice.

Concluding Remarks

Robert M. Sade, MD

News media sensationalized the grave consequences of *M chimaera* infection after cardiac operation after it was reported in 2015 [24, 25]. Recognition of the problem and effective means of preventing it, however, may have reduced the urgency of discussing the details with patients as part of the informed consent process, although feelings remain high on both sides. The main value of the current debate is to highlight the boundaries of the answer to the general question of whether a policy requiring disclosure of low-incidence, high morbidity and mortality complications is ethically required.

One source of guidance our essayists did not explore is published professional and regulatory standards for informed consent disclosure, so it might be useful to visit a few of them briefly.

Professional organizations' guidelines regarding the amount of information requiring disclosure in informed consent discussions are usually too general to provide an answer to the question posed by the PGH vignette. For example, the American Medical Association says this about disclosure: "Physicians should sensitively and respectfully disclose all relevant medical information to patients. The quantity and specificity of this information should be tailored to meet the preferences and needs of individual patients" [26].

The American College of Surgeons states this: "The informed consent discussion conducted by the surgeon should include ... the more commonly known complications, which should be described and discussed" [27]. Both of these guidelines are far too general to help Dr Bellerophon answer the question of whether to require disclosure of *M chimaera* risk.

The most detailed description of disclosure requirements comes from the Centers for Medicare and Medicaid Services Interpretive Guidelines for Hospitals:

The procedure or treatment, including the anticipated benefits, material risks, and alternative therapies, [should be] explained to the patient or the patient's legal representative. (Material risks could include risks with a high degree of likelihood but a low degree of severity as well as those with a very low degree of likelihood but high degree of severity. Hospitals are free to delegate to the responsible practitioner, who uses the available clinical evidence as informed by the practitioner's professional judgment, the determination of which material risks, benefits, and alternatives will be discussed with the patient.) [28].

Thus, by leaving the disclosure of informed consent content to the practitioner's professional judgment, even this detailed guideline does not settle the question of which of our essayists is correct.

Prager, Berlioz, Trachiotis, and Zwischenberger present impassioned arguments for and against advising

Dr Bellerophon to develop a policy for disclosure of this particular risk. Perhaps a third alternative that would be consistent with published guidelines might be to develop no policy at all, leaving individual surgeons to make their own decisions.

Dr Sade's role in this publication was supported by the South Carolina Clinical & Translational Research Institute, Medical University of South Carolina's Clinical and Translational Science Award Number UL1TR001450. The contents are solely the responsibility of the authors and do not necessarily represent the official views of the National Center for Advancing Translational Science of the National Institutes of Health.

References

- Sommerstein R, Rüegg C, Kohler P, Bloemberg G, Kuster SP, Sax H. Transmission of Mycobacterium chimaera from heater-cooler units during cardiac surgery despite an ultra-clean air ventilation system. *Emerg Infect Dis* 2016;22:1008–13.
- Kohler P, Kuster SP, Bloemberg G, et al. Healthcare-associated prosthetic heart valve, aortic vascular graft, and disseminated Mycobacterium chimaera infections subsequent to open heart surgery. *Eur Heart J* 2015;36:2745–53.
- Centers for Disease Control and Prevention. CDC Advises Hospitals to Alert Patients at Risk from Contaminated Heater-Cooler Devices Used during Cardiac Surgery. Available at <https://emergency.cdc.gov/han/han00397.asp>. Accessed March 2, 2018.
- Food and Drug Administration. Update: Mycobacterium chimaera infections associated with LivaNova PLC (formerly Sorin Group Deutschland GmbH) Stöckert 3T Heater-Cooler System: FDA Safety Communication. October 13, 2016. Washington, DC: US Department of Health and Human Services. FDA Med Bull; 2016.
- Firth J. History of tuberculosis. Part 1 – phthisis, consumption and the white plague. *J Mil Veterans Health* 2014;22:22–35.
- Evans S. The white plague: a social history of tuberculosis. Talk presented as part of the series: the Great Plagues: Epidemics in History From the Middle Ages to the Present Day. Gresham College, Cambridge University; Nov 27, 2012; Cambridge, England. Available at www.gresham.ac.uk/lectures-and-events/the-white-plague. Accessed March 2, 2018.
- Tortoli E, Rindi L, Garcia MJ, et al. Proposal to elevate the genetic variant MAC-A, included in the Mycobacterium avium complex, to species rank as Mycobacterium chimaera sp. nov. *Int J Syst Evol Microbiol* 2004;54:1277–85.
- CDC Links Patient Infections to Potentially Contaminated Heater-Cooler Devices. *Quality Advisory* Oct 12, 2016; Available at http://www.oahhs.org/sites/default/files/Quality-Advisory_101216.pdf.
- Society of Thoracic Surgeons. Code of Ethics. Available at <https://www.sts.org/about-sts/policies/code-ethics>. Accessed March 2, 2018.
- McKneally MF, Martin DF. An entrustment model of consent for surgical treatment of life-threatening illness: perspective

- of patients requiring esophagectomy. *J Thorac Cardiovasc Surg* 2000;120:264-9.
11. Sax H, Bloemberg G, Hasse B, et al. Prolonged outbreak of mycobacterium chimaera infection after open-chest heart surgery. *Clin Infect Dis* 2015;61:67-75.
 12. Köser CU, Ellington MJ, Cartwright EJ, et al. Routine use of microbial whole genome sequencing in diagnostic and public health microbiology. *PLoS Pathog* 2012;8:e1002824.
 13. van Ingen J, Kohl TA, Kranzer K, et al. Global outbreak of severe Mycobacterium chimaera disease after cardiac surgery: a molecular epidemiological study. *Lancet Infect Dis* 2017;17:1033-41.
 14. Sorin Group. 3T Field Safety Notice Update - October 13, 2016. 2016 [updated 13 October 2016; cited 2016 24 October]. Available at <http://www.livanova.sorin.com/file/download-5900.action>. Accessed March 2, 2018.
 15. Sorin Group. Field Safety Notice. Cardiac Surgery Mycobacterium Risks Disinfection and Cleaning of Sorin Heater Cooler Devices [Internet]. 2015 [updated June 2015; cited 2016 24 October]. Available at www.livanova.sorin.com/file/download-7391.action. Accessed March 2, 2018.
 16. Garvey MI, Ashford R, Bradley CW, et al. Decontamination of heater-cooler units associated with contamination by atypical mycobacteria. *J Hosp Infect* 2016;93:229-34.
 17. Garvey MI, Bradley CW, Walker J. A year in the life of a contaminated heater-cooler unit with Mycobacterium chimaera? *Infect Control Hosp Epidemiol* 2017;38:705-11.
 18. Centers for Disease Control and Prevention. Contaminated Devices Putting Open-Heart Surgery Patients at Risk. Available at www.cdc.gov/media/releases/2016/p1013-contaminated-devices-.html 13 October 2016. Accessed March 2, 2018.
 19. Meszaros K, Fuehrer U, Grogg S, et al. Risk factors for sternal wound infection after open heart operations vary according to type of operation. *Ann Thorac Surg* 2016;101:1418-25.
 20. Schloendorff v Society of New York Hospital, 211 NY 125, 105 NE 92 (NY Ct App 1914).
 21. Cornfeldt v Tongen, 262 NW2d 684 (Minn 1977).
 22. Fudulu D, Benedetto U, Pecchinenda GG, et al. Current outcomes of off-pump versus on-pump coronary artery bypass grafting: evidence from randomized controlled trials. *J Thorac Dis* 2016;8(suppl 10):S758-71.
 23. Food and Drug Administration. Executive Summary: Nontuberculous Mycobacterium (NTM) infections associated with heater-cooler devices (HCD) during cardiothoracic surgery. Available at <https://www.fda.gov/downloads/AdvisoryCommittees/CommitteesMeetingMaterials/MedicalDevices/MedicalDevicesAdvisoryCommittee/CirculatorySystemDevicesPanel/UCM503716.pdf>. Accessed March 2, 2018.
 24. Winslow R. CDC Links Bacterial Infection in Patients to LivaNova Surgical Device. *Wall Street J* October 13, 2016; Available at <https://www.wsj.com/articles/cdc-links-bacterial-infection-in-patients-to-livanova-surgical-device-1476378132>. Accessed March 2, 2018.
 25. Tavernise S. Bacteria on Device Said to Infect at Least 12 Patients in Pennsylvania. *New York Times* October 13, 2016; Available at <https://www.nytimes.com/2016/10/14/health/bacteria-thought-to-be-from-germany-infected-at-least-12-heart-patients-6-of-whom-died.html>. Accessed March 2, 2018.
 26. Council on Ethical and Judicial Affairs. Opinion 8.08— informed consent. *Code of Medical Ethics*, 2014-2015 ed. Chicago, IL: American Medical Association; 2014:275-84.
 27. American College of Surgeons. ACS Statements on Principles. II.A. Informed consent. Available at <https://www.facs.org/about-ac/s/statements/stonprin#iia>. Accessed March 2, 2018.
 28. Interpretive Guidelines 42 CFR §482.24(c)(4)(v). *State Operations Manual, Appendix A - Survey Protocol, Regulations and Interpretive Guidelines for Hospitals*. Available at https://www.cms.gov/Regulations-and-Guidance/Guidance/Manuals/downloads/som107ap_a_hospitals.pdf. Accessed March 2, 2018.

UNCORRECTED