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Cardiac Surgery 2021 Reviewed

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Abstract

PubMed displayed more than 35,000 hits for the search term "cardiac surgery AND 2021." We used the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) approach and selected relevant publications for a results-oriented summary. As in recent years, we reviewed the fields of coronary and conventional valve surgery and their overlap with their interventional alternatives. COVID reduced cardiac surgical activity around the world. In the coronary field, the FAME 3 trial dominated publications by practically repeating SYNTAX, but with modern stents and fractional flow reserve (FFR)-guided percutaneous coronary interventions (PCIs). PCI was again unable to achieve non-inferiority compared with coronary artery bypass graft surgery (CABG) in patients with triple-vessel disease. Survival advantages of CABG over PCI could be linked to a reduction in myocardial infarctions and current terminology was criticized because the term "myocardial revascularization" is not precise and does not reflect the infarct-preventing collateralization effect of CABG. In structural heart disease, new guidelines were published, providing upgrades of interventional treatments of both aortic and mitral valve disease. While for aortic stenosis, transcatheter aortic valve implantation (TAVI) received a primary recommendation in older and high-risk patients; recommendations for transcatheter mitral edge-to-edge treatment were upgraded for patients considered inappropriate for surgery. For heart team discussions it is important to know that classic aortic valve replacement currently provides strong signals (from registry and randomized evidence) for a survival advantage over TAVI after 5 years. This article summarizes publications perceived as important by us. It can neither be complete nor free of individual interpretation, but provides up-to-date information for decision-making and patient information.

Keywords
- coronary artery bypass grafts surgeryCABG
- aortic valve replacement
- mitral valve surgery
- tricuspid valve

Methods

We used the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) approach for a systematic literature review. The Medline database was searched using the following search terms combined with the publication date being between January 01, 2021 and December 15, 2021 for the different chapters of this manuscript: coronary artery bypass grafting; CABG; aortic valve; mitral valve surgery; tricuspid valve; ascending aortic aneurysm; Type A dissection; LVAD; and heart transplantation. ►**Supplementary Fig. S1** (available in the online version only) shows the PRISMA diagram for the literature review. We selected publications based on their value for indications, decision-making, and patient information. Manuscripts with focus on individual technical details without relevant information for the above described goals were omitted.

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Introduction

The second year of COVID-19 left a mark on the performance of cardiac surgery worldwide. While during the waves, studies report decreased cardiac surgical activity of up to 60%,[1] the average decrease reported for the first year (2020) in Germany was 15%.[2] For less need for ICU capacity, TAVI even experienced increased utilization.

Surgical Treatment of Coronary Artery Disease

Publications in the field of invasive CAD treatment were dominated by the publication of the FAME 3 trial results.[3] This multicenter prospective randomized trial of 1,500 patients from 48 international centers assessed the assumption that modern PCI using guideline conform fractional flow-reserve-guided, zotarolimus-eluting stenting is non-inferior to classic CABG in patients with triple vessel disease. The non-inferiority margin was initially set to 1.45 and later extended to 1.65, which means that both methods are considered exchangeable as long as the combined end point (death, stroke, myocardial infarction or re-revascularization at 1 year) in the PCI group occurs not more than 64% more often than in the CABG group. Despite this generous margin, non-inferiority was not established (►**Fig. 1A**), which means that CABG remains superior to PCI in patients with triple vessel disease despite modern PCI. Except for stroke (0.9% PCI and 1.1% CABG), all individual components of the combined end point were numerically lower in the CABG group. Similar to SYTNAX, the advantages for CABG were most visible in patients with high anatomical complexity and numerically lower death rates were associated with numerically less myocardial infarctions.

This relationship appears to play a key role for survival advantages found for CABG in comparison to PCI. We had suggested the concept of surgical collateralization as explaining mechanism[4] and now published a meta-analysis of all studies having compared CABG and PCI.[5] We demonstrate that a survival advantage for CABG is visible only if the rate of non-fatal myocardial infarctions is also reduced (►**Fig. 1B**). In studies where CABG was not able to achieve lower infarction rates compared with PCI, there was no difference in mortality. These results support the concept of surgical collateralization as an infarct-preventing mechanism, which cannot be exploited by PCI in relevant fashion, because the vast majority of infarctions arise from coronary lesions that are not flow limiting[4,6] and therefore not recommended for PCI treatment.[7]

This recognition also questions the current terminology, because the unifying term "myocardial revascularization" suggests restoration of blood flow as a treatment mechanism, which does not automatically entail the collateralization mechanism of CABG.[8] In addition, even a revascularization-induced change in coronary blood flow may exploit two different mechanisms which appear relevant not only for clinical practice but also for the design of clinical trials and the interpretation of their results. We reviewed this thought in

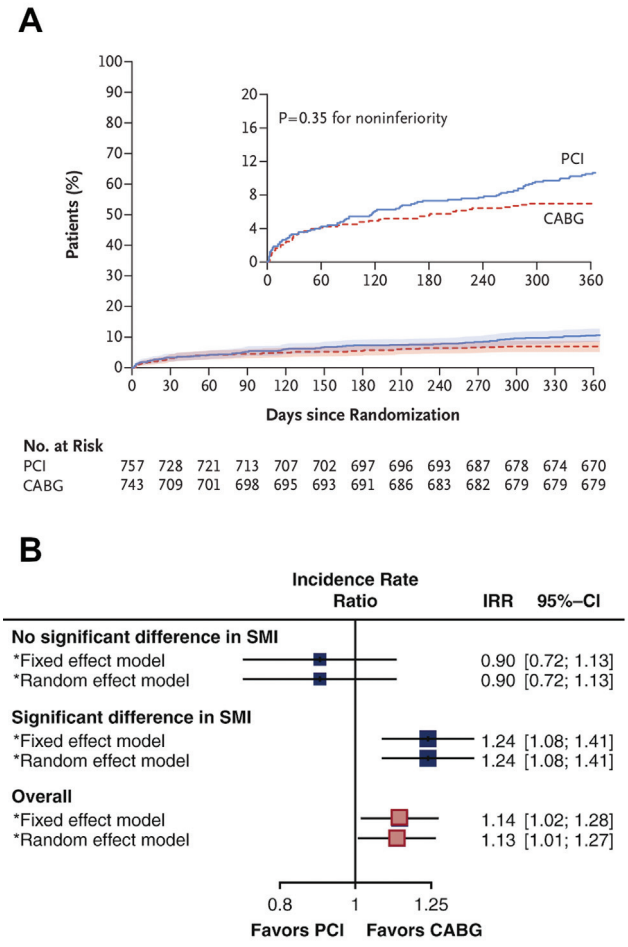

Fig. 1 (**A**) Illustration of the primary end point consisting of death, stroke, myocardial infarction, or re-revascularization within 1 year of the FAME-3 trial having compared coronary bypass surgery (CABG) versus guideline conform, fractional flow reserve-guided percutaneous coronary intervention (PCI) using zotarolimus-eluting stents.[3] Note that the non-inferiority margin of 1.65 for PCI was not met. (Reproduced with permission of Fearon et al 2022.) (**B**) Summarizing Forest plot for all-cause mortality of a meta-analysis including all studies having compared CABG and PCI for multivessel disease. Note, that a statistically significant survival advantage for CABG was only present when spontaneous myocardial infarctions (SMI) were significantly lower compared with PCI.[5] (Reproduced with permission of Gaudino et al 2021.)

detail in 2021.[8] We describe three mechanisms which may differentially be exploited by PCI or CABG (►**Fig. 2**): first, reperfusion in case of flow reductions at rest (i.e., the presence of ischemia). This is the main mechanism for the invasive treatment effect in acute coronary syndrome and potentially hibernation (in case if chronic ischemia actually exists). Second, improvement in coronary flow capacity. This is the main mechanism to be exploited by PCI in patients with inducible ischemia. Since coronary flow at rest is not impaired, this mechanism has the potential to eliminate symptoms on exertion. Both the ISCHEMIA[9] and the COURAGE trial[10] demonstrated, that treating inducible ischemia invasively (predominantly PCI) alleviates symptoms but does not prolong life. Third, infarct prevention. This mechanism is (next to medical therapy, see below) exploited best by a patent

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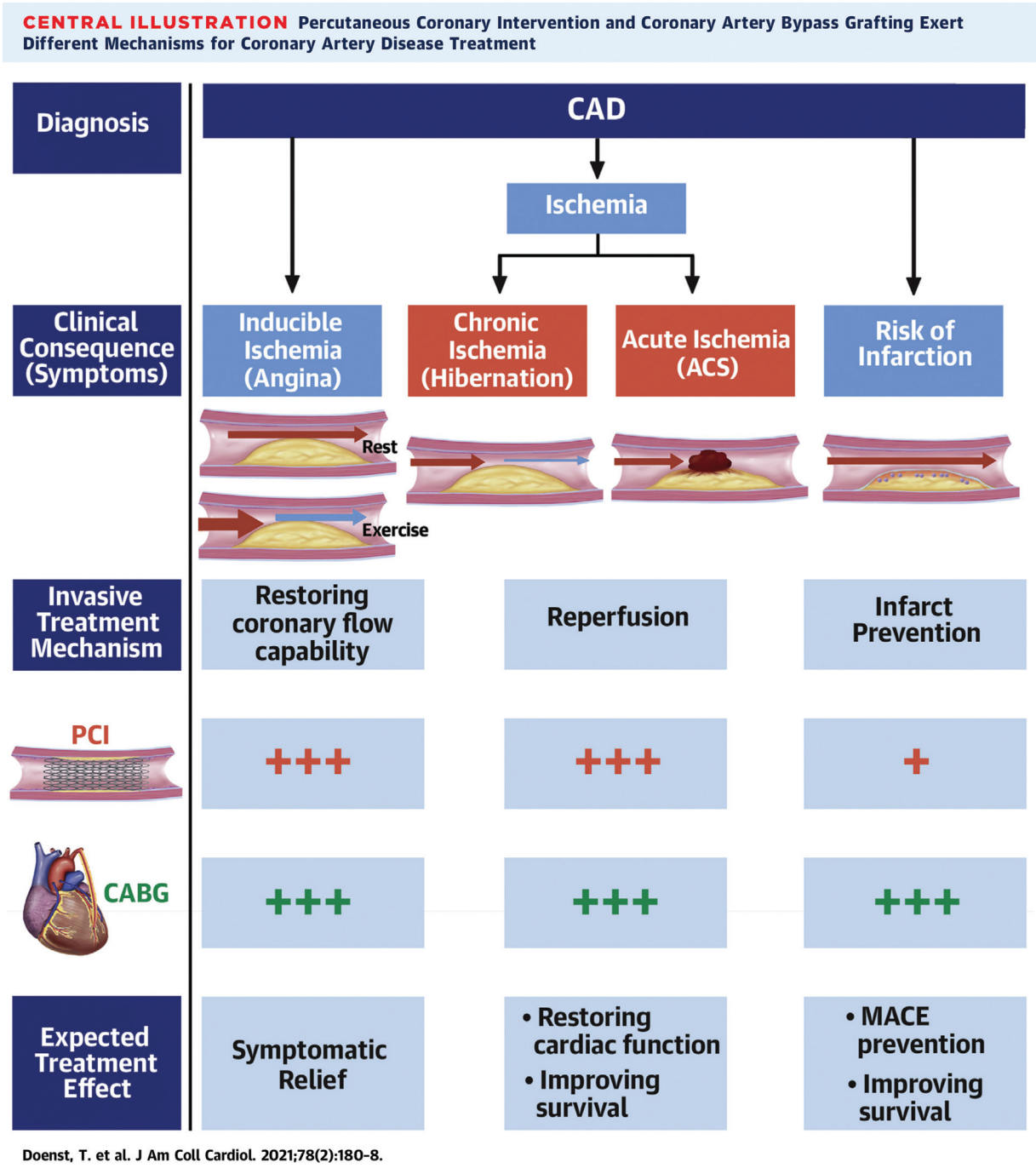

Fig. 2 Central illustration of a topic of the week review addressing the underlying mechanisms of action for invasive coronary artery disease treatment and their treatment effects (Reproduced with permission of Doenst et al 2021[8]).

coronary bypass graft distal to a vessel's CAD (surgical collateralization) and potentially also by stenting an infarct-prone lesion. However, since the vast majority of infarct-causing coronary lesions are not flow relevant,[4,6,8] current state of the art PCI[7] is unlikely to address this mechanism in statistically relevant dimensions, because stenting non flow-limiting lesions is discouraged[7] and potentially even harmful.[11]

Conservative treatment of CAD has made tremendous progress over the years and is an important part of the treatment of every patient with atherosclerotic coronary lesions. In 2021, a sub-analysis of the SYNTAX-trial demonstrated that patients receiving optimal medical therapy at 5 years illustrated a better survival at 10 years than those who did not receive optimal medical therapy.[12] This effect could mainly be attributed to the use of statins and the inhibition of platelet aggregation, which are both associated with infarct-preventing mechanisms. Similar results came from a Swedish registry analysis on patients having survived bypass surgery.[13] In these patients, the intensity of statin therapy was linked to patient survival.

In summary, these considerations suggest that patients with high risk for myocardial infarction derive a survival

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advantage from CABG compared with PCI and on top of medical therapy. Patients with chronic coronary syndrome, should know that invasive treatment of CAD may alleviate symptoms by increasing coronary flow capacity (both PCI and CABG as options), while only CABG appears to be able to prevent myocardial infarctions to a significant degree and potentially prolong life.

The above conclusions are based on observations made in patients with triple vessel disease, presumably because infarction risk is high. In practice, there is often a mix of disease patterns, associated with varying degrees of risk for adverse events. A general debate has been started over the subset of patients with left main stenosis. A recent patient level meta-analysis combining all patients with left main affection (4,394 patients) from four randomized trials (SYNTAX, PRECOMBAT, NOBLE, EXCEL) demonstrated similar survival between CABG and PCI after 5 years.[14] Yet, the authors show a trend toward a greater likelihood of survival with CABG based on a Bayesian analysis, and again, there were significantly less myocardial infarctions during follow-up in the CABG arm (2.6 vs. 6.2% in the PCI arm, HR 2.35, $p < 0.0001$). Since patients with truly isolated left main disease are rare, the analysis may be affected by coexisting single, double, or triple vessel disease with again varying degrees of anatomical complexity and risk of infarction. In addition, the location of the stenosis within the left main stem may be relevant. A meta-analysis comparing distal and proximal lesions with each other demonstrated an association of worse outcome after PCI compared with CABG if the distal left main was affected (which practically requires more complex interventional techniques). However, if only a shaft lesion was present, PCI and CABG were equal.[15]

Randomized trials often exclude subgroups of patients with specific comorbidities. Thus, registry analyses are the only source of information for these patients. In 2021, such reports demonstrated superiority of CABG over PCI in the presence of chronic kidney disease,[16] diabetes mellitus[17] and patients above 80 years of age.[18] Those studies reporting information on myocardial infarctions show again reduced rates of non-fatal myocardial infarction in the CABG groups.

A Swedish analysis addressing patients with ischemic heart failure requires special attention.[19] The authors assessed all patients with an ejection fraction below 50% and at least two-vessel disease from 31 hospitals comprised in the Swedish coronary angiography and angioplasty registry (SCAAR). They demonstrate a significant survival advantage of CABG over PCI in over 2,500 patients in a 10 year period (►**Fig. 3A, B**). Importantly, they also demonstrate stability of CABG procedures in Sweden over time, while there was a consistent increase in PCI procedures in the last decade (►**Fig. 3C**), which is inconsistent with current evidence and with current guidelines. The authors write that risk of death increased linearly with quintiles of hospitals in which PCI was the preferred method of invasive treatment.[19]

Not performing CABG despite primary guideline recommendations is often attributed to the invasiveness of surgery but also to the fear of postoperative complications, specifically neurological events. Trials comparing CABG and PCI

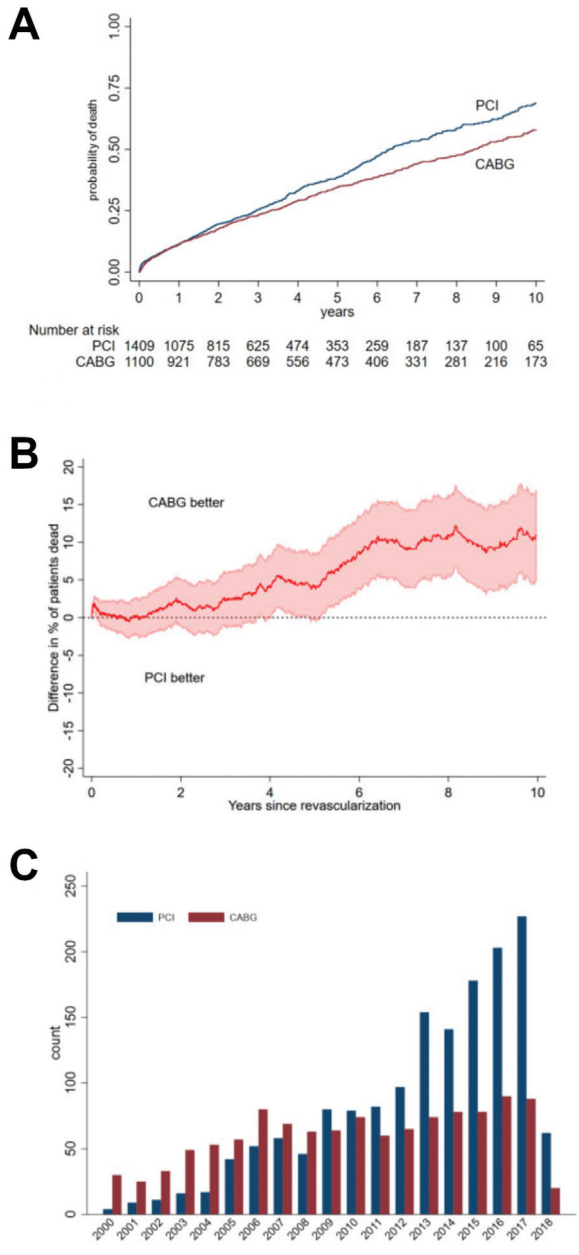

Fig. 3 (**A**) Mortality after PCI (*blue*) or CABG (*red*) from the Swedish coronary artery registry (SCAAR) in patients with coronary artery disease and ejection fractions below 50%. (**B**) Survival advantage calculation in this population. (**C**) Development of both CABG and PCI in the registry over time (Reproduced with permission of Völz et al 2021[19]).

have repeatedly demonstrated numerically higher stroke rates in CABG, although these differences were most often not significant (as most recently in FAME 3, see above[3]). A meta-analysis of 57 studies including 246,340 patients assessed the association of postoperative atrial fibrillation (POAF), the most common postoperative complication, with short- and long-term outcomes. The study associated POAF with increased perioperative mortality, stroke, myocardial infarction, acute renal failure, and hospital stay. Although

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POAF has been considered temporary and rather harmless, there was even an association with long-term mortality, stroke, and long-standing persistent atrial fibrillation.[20] Although a causal relationship between POAF and adverse events has not been established, the following randomized controlled trial[21] is important in this context because it shows an effective way to reduce POAF without increasing the risk of postoperative complications. The authors randomly assigned 420 adult patients without pre-existing atrial fibrillation to undergo posterior left pericardiotomy or no intervention during elective cardiac surgery. They found half the rate of POAF in the posterior left pericardiotomy group (17 vs. 32%, $p < 0.001$), which coincided with similar reductions in postoperative cardiac effusions (12 vs. 21%, $p < 0.001$) and no increase in other complications (►**Fig. 4A**).[21] The next trial will have to test the impact of reducing long-term adverse events through reducing POAF.

In the meantime, resection or occlusion of the left atrial appendage during bypass surgery in patients with atrial fibrillation has been shown to significantly reduce the risk of future neurological events[22] (►**Fig. 4B**). This prospective randomized multicenter trial finds support from a registry analysis from the Cleveland clinic that even shows an association between left atrial appendage occlusion and reduced CABG mortality.[23]

Although clinically relevant strokes are rare, other, diffuse and cardiopulmonary bypass-associated neurological complications are often cause of discussion and fear. An important retrospective cohort study was published in 2021 assessing changes in the rate of memory decline after CABG or PCI.[24] The authors analyzed 1,680 patients with age 65 or older who either underwent PCI ($n = 1,015$) or CABG ($n = 665$) and quantified the rate of memory decline for 5 years before and 10 years after the invasive procedures. The authors demonstrate that there was no difference between the rates of memory decline or dementia probability between CABG and PCI (►**Fig. 4C**). Thus, while neurological complications are certainly part of the "adverse events portfolio" associated with invasive treatments, excessive fear of complications from CABG does not appear to be justified.

A key factor for a CABG treatment effect is patency of bypass grafts. The assessment of a stenosis' flow relevance by fractional flow reserve (FFR, as was used for the PCI arm in FAME 3) has also been suggested and tested for target selection in CABG. A meta-analysis summarizes the results in 2021.[25] While flow-relevant stenoses increase the likelihood for patency of a bypass graft, the evidence also suggests that graft occlusions due to competitive flow (high FFR values in non-flow limiting stenoses) are usually clinically silent.[26] In addition, using FFR for CABG target selection results in the performance of less grafts per patient.[25] Since CAD is a progressing disease and competitive flow does not lead to 100% of bypass graft occlusions, using FFR in CABG for target selection has the potential to reduce CABGs treatment effect (by reducing the number of grafts placed). In addition, patency of bypass grafts is not only influenced by competitive flow (and FFR assessments), but also by technical precision and the type of graft material. Publications in 2021 support not only the value of total arterial grafting based on sub-analyses of the SYNTAX trial,[27,28] but also the value of no-touch vein harvesting techniques for providing excellent patency with vein grafts.[29,30] In addition, FFR assessments comparing patency of venous and arterial grafts demonstrate, that the patency of vein grafts may be less influenced by the FFR values.[31] Thus, a pattern emerges, which appears to display a role for FFR in graft type selection but not in the target selection. Future trials will have to assess this concept.

Conclusion

1. CABG remains the gold standard for the treatment of coronary artery disease, specifically in multivessel disease and/or high anatomical complexity.
2. The mechanisms of CABG (and incompletely so of PCI) consist of reperfusion for ongoing ischemia, improvement of coronary flow capacity for inducible ischemia, and infarct prevention through surgical collateralization.
3. Graft patency is a key for a CABG treatment effect. It may be improved by providing total arterial grafting, applying FFR for selecting graft material, and/or using no-touch techniques if vein harvesting is needed.

Surgical Treatment of Valve Disease

Valve therapy was characterized in 2021 by the publication of the new ESC/EACTS guidelines,[32] which include a thorough overview of the available evidence. We therefore here provide only some selected surgical perspectives based on most recent publications. In general, the guidelines have increased recommendations for interventional treatment of structural heart disease. Transcatheter valve implantation (TAVI) has received a primary recommendation for older and higher risk patients. For the mitral valve, interventional techniques have been upgraded for those patients who are not suited for a surgical procedure. Emphasis is placed on individual decision-making by the heart valve team. While interventional valve treatments demonstrate staggering growth rates, classic cardiac surgery has also progressed, specifically to less invasive, often sternotomy-sparing procedures. This development becomes also evident by assessing the 2021 publications.

Aortic Valve

The new guidelines give a primary recommendation for TAVI in patients above 75 years of age and those with an EuroSCORE II above 4%.[32] The final recommendation is supposed to be individually adjusted by the heart valve team. From a classic surgical perspective, it is important to know that both registry data and randomized evidence demonstrate a remarkable signal for better survival at 5 years (►**Fig. 5A, B**),[33–35] although the difference has not become apparent in individual randomized trials (including the most recent presentation of the SURTAVI 5 year outcomes[36]). This may be the explanation for the fact that the prognosis of the patient is not mentioned as decisive factor between the methods in the guidelines.

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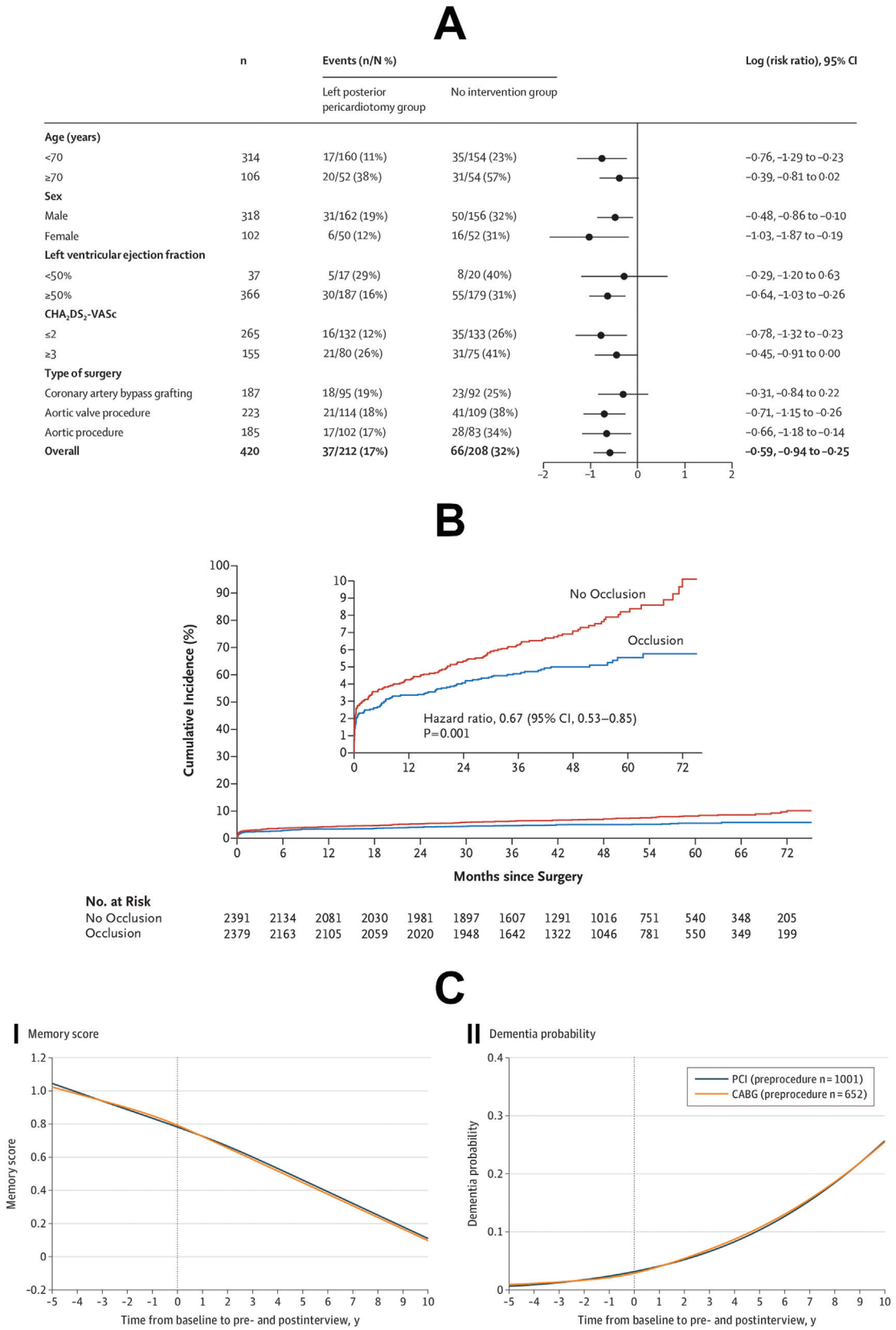

Fig. 4 (A) Subgroup analysis of a prospective randomized trial on 420 patients undergoing cardiac surgery with or without posterior left pericardiotomy (Reproduced with permission of Gaudino et al 2021[21]). (**B**) Stroke rate during follow up after coronary bypass grafting in patients with additional atrial fibrillation having or having not received-atrial appendage occlusion or resection (Reproduced with permission of Whitlock et al 2021[22]) (**C**) Memory score (I) and dementia probability (II) of CAD patients five5 years before and 10 years after CABG ($n = 665$) or PCI ($n = 1{,}015$). Note that neither CABG nor PCI affected these functions in a relevant fashion (Reproduced with permission of Whitlock et al 2021[24]).

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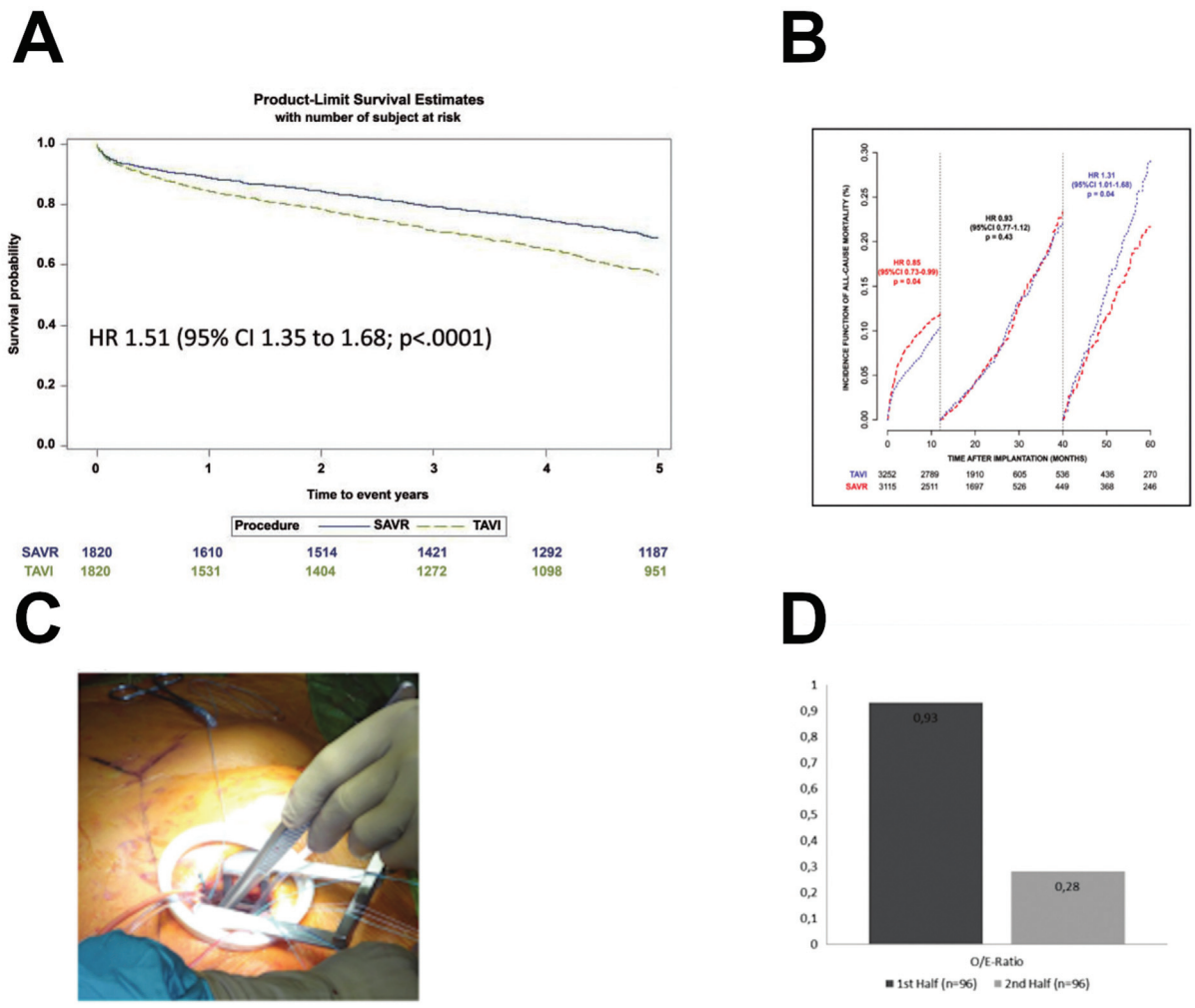

Fig. 5 (**A**) Survival after TAVI or SAVR in propensity-matched patients from the Germany Aortic valve Registry (GARY) (Reproduced with permission of Beyersdorf et al 2021[38]). (**B**) Landmark analysis from a reconstructed individual patient-data meta-analysis having included all randomized trials with 5-year follow-up comparing SAVR and TAVI (Reproduced with permission of Doenst et al 2021[34]). (**C**) Intraoperative photo of a surgical aortic valve replacement through a parasternal minimally invasive access (Reproduced with permission of Doenst et al 2021[34]). (**D**) Observed to expected mortality of parasternal SAVR during (*dark gray bar*) and after (*light bar*) the learning curve (Reproduced with permission of Doenst et al 2021[34]).

While durability is no explanation for the mortality differences[37] most prominently observed in propensity-matched registry analyses,[38] the combination of other adverse events may be plausible. Several registries illustrated that mild paravalvular leaks (more frequent in TAVI) may already be prognostically relevant.[39,40] The need for pacemaker implantations may be up to five times higher with TAVI[41] and may[42] or may not[43] be associated with decreased prognosis. In addition, TAVI is associated with a three to fourfold higher rate of cusp thrombosis,[34] which is associated with an increased risk of stroke during follow-up.[44] Finally, it was demonstrated that the extension of TAVI procedures to new centres with regional condensation results in decreased quality of care.[45]

While it is argued that many of the trials used devices that have been improved, it is important to note that classic surgery has also developed during this time. This became prominently evident in the FAME 3 trial, where enrolled patients were practically identical to the SYNTAX trial, but they only experienced half of the adverse events than in SYNTAX in both treatment arms. In valve surgery, the fraction of patients receiving isolated or combined surgery through full sternotomy is continuously decreasing.[2] Although PARTNER 3 data comparing full to partial sternotomy did not illustrate differences,[46] individual center experiences display perioperative outcomes for aortic valve replacement that do not differ in risk from the transfemoral results published in randomized trials (►**Fig. 5C, D**).[34,47,48] Thus, individual decision-making, taking local expertise, and prognosis for the individual patient into account seem to be the most promising way for optimal patient care.

Mitral Valve

The new guidelines have also updated recommendations for treatment of the mitral valve. Classic surgery remains the gold standard for the treatment of severe mitral regurgitation. This is the case for both structural and functional MR,

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although "enthusiasm" for surgery of functional MR has suffered and recommendations for transcatheter edge-to-edge therapies (TEER) have gained in relevance.[32] While indications for treatment of structural MR are based on both prognostic and symptomatic goals, the life-prolonging effect of surgery for functional MR remains questionable. Prospective randomized evidence for survival impact of functional MR treatment is currently only available from the COAPT trial, which compared the MitraClip to conservative treatment in patients considered inoperable. Although this survival advantage was also demonstrated after 3 years of follow-up,[49] two main issues substantially limit the trial's impact on treatment recommendations. First, the MITRA FR trial, that compared MitraClip to conservative treatment in similar patients, showed no difference between groups at all. Second, the echocardiographic data from the COAPT trial are highly implausible and therefore prevent recommendations for patient selection based on echocardiography.[34,47] The trial published a regurgitant volume of 60 mL in patients that have a 60 mL total stroke volume (ejection fraction of 31% at 194 mL end-diastolic volume). A theoretical concept of proportionate and disproportionate MR was published by the COAPT-protagonists to explain this discrepancy.[50] However, a recent publication by the COAPT-group themselves failed to support this concept based on their own data.[51] While the concept of proportionate and disproportionate MR was mentioned in the guidelines,[32] the repeatedly published criticisms on the echocardiographic inconsistencies[34,52] found no mentioning. Nevertheless, basing recommendations to select (so called COAPT-like) patients on such echocardiographic assessments appears highly questionable.

It is important to know for daily practice, that patients who received TEER, have a very low likelihood of receiving mitral valve repairs in case surgery is still an option. Two publications in 2021 illustrate these statements based on the CUTTING EDGE registry (over 300 patients) and the STS database (over 500 patients).[53,54] Both studies show higher than expected mortality and illustrate that only 5 to 10% of patients received repairs, although repairability was expected in over 90% of cases based on the initial pathology (►**Fig. 6**). Since mitral valve replacement is associated with poorer survival than mitral valve repair,[55–57] this finding is important for individual assessment by the heart valve team.

In general, the goal of treating mitral regurgitation must be its complete and durable elimination. For structural MR, repair success and durability have been documented in the best possible way. Even in most complex mitral valve pathologies (e.g., bileaflet prolapse in Barlow's disease), mitral valve competence can be restored durably without opening the sternum using individualized repair concepts. We suggested the concept of symmetric and asymmetric Barlow's, where in symmetric cases an isolated ring annuloplasty may suffice for a durable repair,[58] which may facilitate at times very complex repair procedures.

For isolated posterior prolapse, a meta-analysis compared neo-chordal resuspension of the prolapsing segments with classic resection techniques.[59] The study found larger annuloplasty rings in the resuspension groups which was associated with lower transvalvular gradients and better ejection fractions. With the rapid development of interventional techniques, neo-chords can now also be introduced transapically or transeptally. A recent review article illustrates these techniques and describes the first in human experience.[60] From a practical standpoint, durability remains the question here, since these techniques do not include an annuloplasty, thus far.

A daily practical question addresses the need for anticoagulation after mitral valve repair. A meta-analysis on over 2,000 patients with mitral valve repair and sinus rhythm, shows that warfarin compared with platelet inhibition neither affected stroke nor bleeding rates.[61] Thus, the results question current guideline recommendations for patients who are in sinus rhythm after surgery.[32] A Brazilian prospective randomized trial then addressed the question of anticoagulation in patients with atrial fibrillation who had previously received a bioprosthesis in the mitral position.

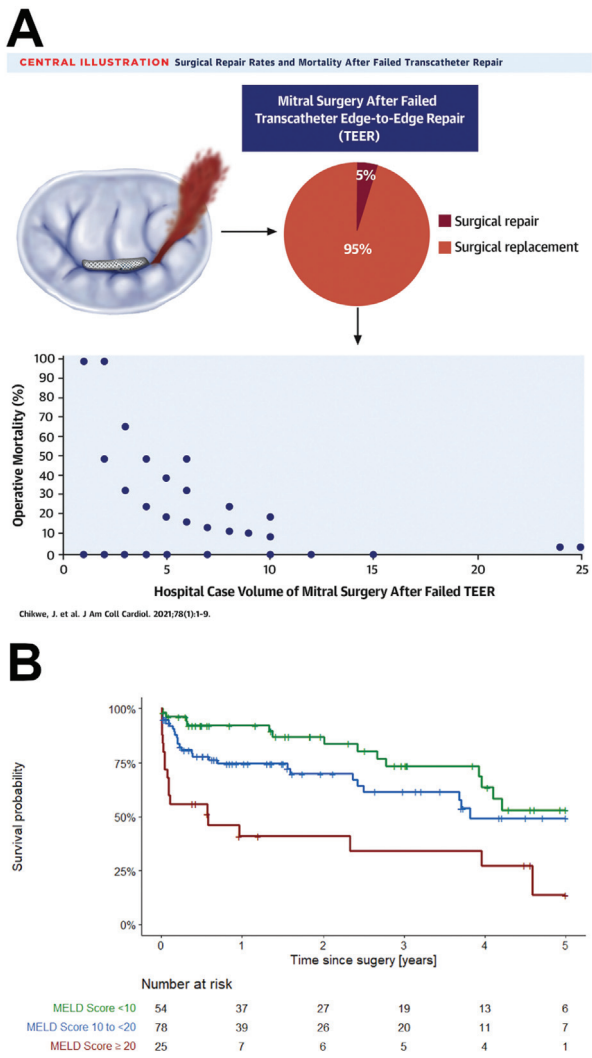

Fig. 6 (A, B) Central illustration of a study assessing the outcomes of mitral valve surgery after failed transcatheter edge-to-edge repair (TEER) in patients with either structural or functional MR. Note the high rate of valve replacement and the increasing mortality with lower case volumes (Reproduced with permission of Chikwe et al 2021[53]).

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Here, rivaroxaban as new oral anticoagulant was non-inferior to classic warfarin in over 1,000 randomized patients.

Tricuspid Valve

Invasive treatment of tricuspid regurgitation (TR) has moved into focus over recent years. While tricuspid valve surgery has generally been considered high risk, more and more evidence comes to light demonstrating that not the surgical procedure per se but the existing comorbidities at the time of treatment reflect that risk.[34,47] The pathophysiology of TR has moved the liver into the focus of attention. A retrospective study on 85 patients having undergone isolated tricuspid valve surgery between 2005 and 2019 showed significantly increased mortality in patients with a MELD XI score above 12. In addition, we demonstrated in 157 consecutive patients having undergone isolated tricuspid valve surgery between 2011 and 2019, that classic risk score predictions substantially fail to even come close to true mortality in patients with MELD scores above 20.[62] These two publications pave the way for better treatment recommendations, because they allow identifying the true high-risk patients.

This information is urgently needed, because TEER techniques are developing rapidly, and are lower in peri-procedural risk but do not provide the same repair result than a surgical procedure. Current publications in this area suggest an association between the reduction of TR and improvement in symptoms.[63,64] Considering the huge amount of patients with severe TR who are not offered any form of invasive treatment in the moment, this new information together with our improved ability for risk assessment provides an excellent perspective for many symptomatic patients.

Most often, TR is a part of mitral valve disease. The American cardiothoracic surgical trials network (CTSN) published the results of their tricuspid trial, where patients who underwent mitral valve surgery with mild to moderate TR but with evidence of tricuspid annulus dilatation (above 40 mm) were randomized to additional tricuspid valve repair or isolated mitral surgery. On over 400 patients in the two groups, the trial demonstrated that concomitant tricuspid repair reduced the occurrence of relevant TR during the 2-year follow-up, but these (thus far echocardiographic) outcomes came at the cost of a higher need for postoperative pacemakers.[65]

Two additional studies addressed the role of a tricuspid repair in the context of aortic valve replacement. While one of the retrospective data analyses suggested an improvement in outcome through additional tricuspid repair,[66] the other suggested the opposite.[67]

The main findings of 2021 for classic valve surgery are:

- Patients requiring aortic valve replacement may have a survival advantage with classic aortic valve replacement after 5 years. This information is not specifically addressed in the guidelines but may be relevant for decision-making for the individual patient.
- Mitral valve surgery remains the gold standard for the treatment of mitral regurgitation. The lack of evidence for a prognostic effect of surgical treatment of functional mitral regurgitation dampens enthusiasm in light of the currently less effective but safer interventional alternatives.
- Treatment of severe TR is associated with improved clinical outcome. Assessing liver dysfunction (e.g., using the MELD score) appears useful in selecting the optimal individual invasive strategy.

Glimpse into Surgery of the Aorta and for Terminal Heart Failure

One of the most prominent treatments for aortic disease is surgery of Type A dissections. In 2021, the perception that the more aggressive approach replacing the total arch potentially including the head vessels provides better long-term outcomes was reinforced.[68] However, this better long-term outcome comes with a higher perioperative risk. Thus, similar to the evaluation between surgical and interventional approaches for coronary treatment or valve disease, the perioperative risk must be weighed against potential long-term benefits. The less aggressive partial arch replacement with shorter circulatory arrest times and periprocedural complications has just been associated with a higher rate of residual dissections and new entries at the distal anastomotic site in a meta-analysis.[69] Thus, a current expert consensus comes to the recommendation that arch replacement potentially including elephant trunks may be an option in experienced hands.[68–71]

In the treatment of terminal heart failure, the continuing shortness of donor organs makes left ventricular assist device therapy more and more a long-term alternative to heart transplantation. A meta-analysis demonstrated that left ventricular assist device therapy is able to provide similar 2-year survival compared with heart transplantation.[72] However, there appear to be more strokes associated with the assist device therapy.

Conflict of Interest
None declared.

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