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Research Article

**KNOWLEDGE ATTITUDE AND PRACTICE REGARDING THE
INTERVENTIONAL CARDIOLOGY (IC) REGIME; PRESENT
AND FUTURE INNOVATIONS****Rehan Shahid¹, Khadeeja Mustafa², Shair Ismail², Muhammad Umar Hassan³, Ali Husnain³, Sidra Akram⁴, Muhammad Hamza Sarfraz³, Syed Mujtaba Haider³, Muhammad Ahmad Fahim³, Ahmad Ismail³**¹ Punjab Institute of Cardiology, Lahore, ² Punjab Medical College, Faisalabad, ³ King Edward Medical University, Lahore, ⁴ University of Central Punjab, Lahore.**Article Received:** September 2021 **Accepted:** October 2021 **Published:** November 2021**Abstract:**

The clinical field of interventional cardiology proceeds to progress rapidly. The effectiveness of percutaneous interventions with recent generation drug-eluting stents has progressed a lot over the previous decade. This development in stent performance has expanded the level of evidence towards more complicated interventions such as left main and multi-vessel PCI. Primary improvements continue in the field of medical co-therapy such as antiplatelet therapies (bivalirudin, prasugrel, ticagrelor) and this will further improve outcomes of PCI. Various specific new technologies are poised to enhance the treatment of cardiovascular disease patients and at the same time the safety of the physicians who care for them. These include high resolution CT coronary imaging with fractional flow reserve (CTCAFFR), virtual reality, vascular robotic systems, and three-dimensional printing. This paper strives to encompass all the present and futuristic innovations that have been introduced in the field of interventional cardiology. It focuses on the probable clinical impact each of these modalities will have, as well as inferring on synergies that practice of them together may achieve.

Keywords. *Interventional Cardiology, Clinical Cardiology, Coronary Procedures*

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INTRODUCTION:

Cardiovascular disease is the main source of demise on the planet and surpasses the amount of deaths because of different illnesses, for example, malignant growth and AIDS. According to the data of World Health Organization, 30 % of all worldwide deaths is credited to various cardiovascular disorders, and in spite of the impressive advancement in the therapeutic methodologies, the number will keep on expanding in the following many years [1].

Other than drugs, which address the crucial system in essential and supplementary counteraction, percutaneous transluminal coronary intercession has quickly turned into the fundamental remedial procedure for cardiovascular diseases and overall quantities of coronary mediations surpass coronary bypass tasks. Since the pioneer Stephen Hales set the primary catheter for correction in the ventricle of an alive pony in 1711, it required over 150 years before the strategy was related to people. In his spearheading self-explore, the famous Werner Forssmann went through the primary man heart invasive catheterisation in 1920s. The main cardiac procedure in an alive individual was an inflatable balloon catheter, acted in 1970s by researcher Andreas Grüntzig while being in Zürich. This progressive technique has been taken on via cardiologists quickly and was additionally grown, so after nearly 10 years, the main coronary stent called as Bare Metal stent (BMS) manifestation was acted in. The stent implantation has effectively beaten the adverse renovation and defective re-narrowing of the vessels, decreasing the ratio of restenosis to roughly 15–30 % contrasted with 30–60 % even after the mechanical dilatation. Additionally, the thrombotic impediment or analyzations after expansion could be viably treated. Accordingly, in April-May 2000, the famous National Institute for Health and Care Excellence (dubbed as NICE) in the United Kingdom pronounced coronary stent implant as basic technique for patients experiencing a myocardial infarcted tissue [2].

Latest Advances in Interventional Cardiology:

Kicking on from decades, clinicians and cardiologists have come a long way. The following innovations define the IC practices in recent times

Transcatheter Realtime aortic valve Replacement:

This system has been described by its huge growth established upon the enormous neglected clinical requirements. In the early excursion of transcatheter aortic valve replacement (TAVR), rules for establishments and particular administrators and an

order for a public library were proposed by proficient social commissions to work with "judicious scattering" of the innovation to painstakingly chose destinations with expansive geographic conveyance. Concordant with these endeavors, the field progressed quickly because of the fruitful consummation of additional randomized trials that organized TAVR as superior and, in certain viewpoints, better than traditional methods paying attention to comprehensive problem (4). As this groundbreaking innovation keeps on drastically affecting consideration in the following decade, significant inquiries with respect to its indication, organization, and guideline will keep on going to the cutting edge [3,4].

Transcatheter methods for stroke deterrence:

The duty of transcatheter intercessions for ischemia avoidance has generally been restricted. Nonetheless, 2 significant turns of events as of late resulted in the field. To start with, the U.S. FDA supported the initial left atrial gadget for stroke downregulation in chosen cases with non-valvular atrial fibrillation Problems. Second, a few crucial preliminaries indicated the prevalence of persistent patent foramen ovale closure over clinical treatment in patients with proven cryptogenic stroke and PFO making ready for the authorization of PFO decision. Given the enormous pool of patients who might benefit from these systems, a substantial growth in IC practices in this area can be projected effectively. Nonetheless, the interventional stroke management field is in its earliest stages, and neglected clinical needs and open inquiries stay the objective of a large portfolio of continuous examinations. Those include the shared dynamic cycles, post-procedural clinical treatment, the effect of peri-gadget hole and gadget clots, the comparative effectiveness with direct anticoagulant [5].

Effective endovascular interventions:

Since legendary Dotter played out the principal percutaneous trans-luminal angioplasty (dubbed PTA) in 1964, endovascular prevalent interventions advanced considerably to include several methods in numerous vascular locations. Despite the fact that introductory vigor in regards to stenting of primary carotid and renal circuits was hampered by the restricted information prompting a generous decline in their amounts, other effective endovascular interventions thrived including but not limited to stenting for torso and lower extremity blood vessel disease, experimental graft stenting for acute aneurysmal disease, and catheter-assisted monitored thrombolysis for clotting and thromboembolic

disorder. Due to the decrease in the quantity of PCIs for predictable limited effects CAD over the most recent twenty years, endovascular interventions became a space of developing interest between interventional cardiologists. A modern area of developing interest somewhat recently is transcatheter automatic thrombectomy for severe stroke. Albeit mechanical and automatic thrombectomy methods have been used for longer than 10 years, the distribution of 5 positive milestone preliminaries in 2015 set up a focal job for mechanical thrombectomy in current stroke supervision and prompted a substantial expansion in procedural quantity [6].

Drug or Medication Coated Balloons (DCB):

Medication covered inflatables or Drug Coated Balloons were acquainted in 2003 with treatment of stent restenosis, and were supposed to be a choice to expand angioplasty, too, when the required position was impractical or alluring. They have likewise been concentrated in lower limit peripheral vascular ailment where the vessel blocks stent placement. Compliance of the antiproliferative medication is typically refined by utilization of an external agent that works with drug take-up by the vessel. The underlying gadgets utilized paclitaxel as the leading antiproliferative specialist, yet as of late sirolimus DCBs have been created. [8]

Blended outcomes have been seen when DCBs have been contrasted with DES in once more injuries with most investigations showing a less ideal result. The discoveries in preliminaries of DCBs in vascular disease have shown that DCBs are better than swell angioplasty alone. The job of these gadgets later on will probably be for the therapy of in-stent restenosis and in troublesome life systems where stenting isn't suggested. [8]

Bio- degradable Stents:

Second era and generation stents have been displayed to furnish simpler passage and are related with inferior stent thrombosis ratios and have cut dian on long haul results in correlation with the original DES . The more slender structure and more adaptable design combined with the utilization of more powerful antiproliferative agebts , for example, everolimus along with biolimus, and tachrolimus in correlation with sirolimus and tested paclitaxel have been capable. The everolimus cobalt stent, specifically, has been displayed to bring about a decreased late stent induced thrombosis rate

in correlation with exposed metal pieces and is one of the most usually utilized equipment nowadays.

All metallic stents adequately give a platform that forestalls pliant and elastic recoil and precisely hold the inflatable against the vessel side . Notwithstanding, when healing is finished, the existence of the stent is presently not required and might be a weakness by forestalling rebuilding of typical vessel vaso-motion and favorable vascular redesigning. Stents additionally can impede approval to side tributaries and limit the overall choice for solution of in-stent restenosis. What's more, a wide range of metal stents keep on having a low yet consistent pace of extremely overdue stent apoplexy (0.2%–0.4%/y) for quite a long time after implantation in spite of delayed double antiplatelet treatment [4,9].

Bio-absorbable stents have been acquainted with reducing these limits of conventional stents. First concentrated in the early1990s, it was not until the beyond a certain period that randomized clinical examinations of the everolimus bioabsorbable vascular platform (formed by ABSORB and Medtronic) have been published. The stent is made out of high-atomic weight poly-L-lactate that reduces by breakdown and assimilation of the metal over a year time frame. It was presented clinically in 2007-2008 and has been displayed to give magnificent adequacy and security in non-randomized trials. This stent was endorsed for use in Europe in 2010s. Independant Vascular reaction studies have shown that the vessel portions react typically to vaso-dilators and constrictors after 10 to 24 months. The absence of metal grants representation of the conduit fragments with electronic tomography that permits noninvasive monitoring of patients over the long run. [9] (The comparison of efficacy various stents has been shown in Fig 1)

Observational investigations of the original solutions have recommended that these benefits may partially be inferable from a provocative reaction that blocks mending and healing. Driven investigation of patients who passed on of delayed stent clotting and investigations of clots element suctioned at the hour of delayed stent thrombosis both exhibit proof of eosinophil invasion, steady with a hypersensitivity response [7].

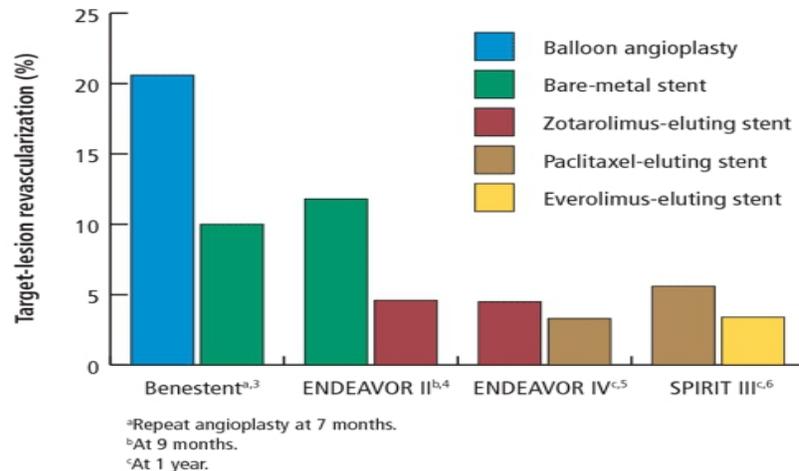


Fig 1 Comparison of Efficacy of various stents

Role of Precision medicine:

Precision medication or "customized medication" is ready to turn into a foundation of future clinical diagnostics and treatments. The center of this thought is to utilize individual indicative information from the subject to adapt a particular remedial item for that person from whom the information are acquired. Using innovation to tailor treatments for a singular patient endures the guarantee of diminished expense, expanded adequacy, and further developed wellbeing. This thought has become such an interesting issue that the US FDA has as of late created an original copy enumerating a guide for its job in customized medication . This subject of accuracy/customized medication is additionally acquiring force in interventional cardiology. A few explicit new advances are ready to work on the treatment of cardiovascular illness patients and simultaneously the wellbeing of the doctors who care for them: high contrast CT coronary imaging (CTCAFFR), computer generated reality, vascular mechanical frameworks, and three dimensional printing [10].

What does the future hold?:

While the exact degree of future technology remains elusive, we can speculate immediate further practices by analysing what is being introduced right now. Some of these are as follows

Computer generated reality or VR:

Augmented Reality plus Virtual reality (VR), or PC simulated reality, recreates a climate that reenacts an actual existence in places in reality or an envisioned realm, permitting the client to cooperate in that mimicked community. This is cultivated by gadgets that reenact (on screen) a simulated and virtual

portrayal of the real world, or by utilizing various headsets, which confer an additional vivid first-individual experience . Partnership with the virtual climate can be accomplished in various manners, including through customary PC input (console, mouse) or devices that are intended to recreate the sensation of the genuine encounter itself. The clinical arena has been probably the greatest adopter of this innovation over the previous decade, especially in the areas of procedural preparing and automatically a practical medical procedure. Preparing future specialists with VR programming is a protected and viable interaction that permits students to foster basic active specialized abilities without the chance of hurting a "live" subject . [11] VR, in technological blend with careful advanced mechanics, permits an administrator to stand away from a patient and regulate an automated arm by means of sensitive expansions resulting in more modest cuts prompting less blood, misfortune and quicker comeback for patients. An urgent factor in this VR automated framework is material objection, and VR frameworks are presently fusing haptic innovation into their systems. This "submersion innovation" permits further developed impression of the working robot unit by the supervisor controlling the gadget, empowering him better accuracy. This innovation has additionally been pertained to the region of telesurgery, where specialists can work on patients distantly by means of a control center in a totally discrete area . Making an interpretation of this innovation into the space of clinical interventional cardiology would permit administrators to conduct essential PCI on serious patients that exhibit ST height myocardial areas of localized necrosis submitting to non-PCI able offices, working with brief automatic revascularization. It

would have recently assigned thrombolytic treatment or move to a PCI eligible office otherwise. [14]

One more utilization of VR is in preparation or as we call it peri procedural arranging. Utilizing VR to rehearse techniques is modern, however not novel at all. For instance, the useful Dextro-scope and innovative Dextro-Beam (used for Bracco Imaging) are revolutionary VR frameworks intended to do exactly that, permitting the client to make an implied patient. This said virtual or projected patient is a three dimensional picture created from projected DICOM information from numerous applied tomographic sources (these include CT, CTA, MRI, MRV, SPECT and PET). At the point when the administrator sits at the control center, he can genuinely control the created configuration with hands, permitting exact estimations. This kind of VR innovation has been generally used in the profession of modern neurosurgery, yet has possible use in interventional cardiology [15].

Vascular Robotics:

Each heart intervention is right now accomplished by hand-control of inflatable balloons and stents along with other different gadgets. While this method has been incredibly effective, it has some significant downsides: the supervisors should open exposure to radiation. Additionally There is dependence on human borne reflexes. Vascular mechanical frameworks

(dubbed VRS) can possibly upgrade the exhibition of cardiovascular strategies by diminishing the related dangers looked by interventionalists and specialists in the Cardiac Catheterization laboratory (termed CCL) while furnishing patients with worked on processing results. Researches previously presented the idea for human use in 2005- 2006 as a Remote Navigation System that would be independent to some degree [4,11]. This framework comprised of a touch-screen and a joystick regulator set at the end of the CCL platform where the supervisor monitored guidewires, directing catheters, and inflatable catheters by means of a bed-side unit or gadget pilot. The said RNS showed decreased radiation openness to administrators and proposed conceivable further developed accuracy with stent arrangement. Refining this idea and plan, the CorPath 200 mechanical framework was created and has been by far the most contemplated VRS till now (Fig 2). It comprises of a radiation-ensured, ergonomic operating desk from which administrators regulate guidewires and the conveyance of inflatables and specific stents, and a mechanical thrust at the table- side that clasps a clean single-use tape including spots for guide- wires and a usable stent catheter. For subjects, mechanical percutaneous coronary intervention (or PCI) may upgrade safety through possible enhancements in fitting stent measuring and more exact gadget conveyance, restricting longitudinal topographical miss [16]



Fig 2. CorPath 200 mechanical Framework

Dimensional Printing:

Around the previous decade, the 3 dimensional printing has arisen in a large number of clinical settings from giving new medicines to working on quiet results and protecting lives. The center thought around 3DP is the formation of a material

manifestation from a computerized record, utilizing printers that make the actual item utilizing an assortment of materials. It is a point with extraordinary interest in the clinical and careful local area, and has even motivated a whole diary committed to the conversation of 3D printing strategies. An advanced

article can be made from computer aided or generated design (as CAD) using a 3D displaying procedure for another item or a 3D scanner for an all around existing item. When a picture is made, the picture should be changed over into a viable Standard Tessellation computer Language (STL) record and this draft is then shipped off a three dimensional printer which then, at that point stores the element in a language and virtual manner ²¹. This is ordinarily conducted by added substance producing, or layerby-layer, instead of subtractive assembling, or processing. The sorts of materials that are being utilized are fluctuated, contingent upon the procedure, and can incorporate various plastics, filaments, glass, and sometimes metal. In the domain of cardiovascular medication, creation of 3Dimensional models through projecting and printing currently assumes a part in the careful perioperative arranging, careful imitation, and intra-operative direction for a provided patient's special life structures. This has been especially useful in the treatment of intricate inherent coronary illness. 3DP additionally has the capacity for working on the arranging of coronary mediations. Instant restenosis has for quite some time been the "weak spot" of interventional and clinical cardiology, yet has enhanced with more current age drug infused stents. For analysis Wang and partners portrayed a strategy for diminishing ISR by ideal stent situating dependent on a 3Dimensional model made using advanced angiography of genuine interventional case as the computerized file. The experimental in vitro micro-fluidic 3Dimensional prototype was then tried along with stents put in various places of a coronary borne stenosis. Ideal stent situating not really set in stone through computational fluid elements (CFD) to characterize spaces of most noteworthy division shear pressure that predicts diminished ISR. [20]

CT Coronary Angiography:

Cardiovascular disorder is as yet the chief reason for sudden deaths in the United States. More than 15-16 million patients each year look for direction in regards to cardiovascular issues, and perhaps the biggest space of interest is in the assessment of chest anguish, coronary disorders and infection. The assessment of a case for coronary illness is tricky, as the affectability of formal pressure assessment is just around 85%, and intrusive testing (the best quality level) is additionally tedious, expensive, and accompanies some inborn dangers. When tomography turned out to be sufficiently quick to acquire clear pictures of the pulsating heart, it has mostly been utilized for getting non-obtrusive demonstrative pictures of the heart supply routes just as the bigger designs of the heart. Late information recommends that CTCA is much

more precise than the conventional stress-testing for the existence of clinically important coronary illness in suggestive people, while presenting patients to smaller radiation. Notwithstanding morphologic distinguishing proof of the existence of coronary vascular atherosclerosis, new strategies, for example, the clinical fractional flow reserve CT (FFRCT) permit much better separation between those sclerotic plaques which are and at the same time, are not practically stenotic, like intrusive FFR in the lab. [13] Entering in on specific plaques that are effectively causing indications takes into account further delineation of provocative sufferers in whom coronary mediation is fitting, and explicitly which parts are deemed the "offender." What is much more energizing is simply the possibility that CT (can be either or related to positron outflow tomography dubbed as PET-CT) might conceivably decide arrangement and delicacy of plaque, and subsequently which vascular plaques are bound to cause significant clinical issues later on. This would hypothetically take into account prophylactic management and stenting of weak plaque to forestall coronary vascular events, something that has not until recently been shown to be a compelling treatment technique. [12]

Restrictions:

There are a few genuine gaps in executing a particularly incorporated methodology: Currently there is no product answer for taking 3Dimensional CT pictures and transform them into the sort of records (also called stereolithography) that are utilized by most 3Dimensional printers. CT organizations and diagnostic imaging programming organizations are attempting to give rise to something less unwieldy. Computer generated reality, while accessible in a restricted design or using improvement packs, is as yet not exactly accessible for proficient buyers. High-goal headsets from a few organizations including but not limited to Oculus Rift™, Sony™, and Samsung™ ought to be accessible worldwide. Presently there are no "off the rack" methods of coordinating these headsets with current test systems or mechanical technology frameworks. The mechanical technology frameworks themselves are currently being utilized clinically, however they are costly, and are not accessible in most labs. Publishing 3D articles has taken off, and are accessible at a sensible expense, but here would be various issues that would should be tended to before printed stents could be embedded in people (disinfection strategies, security issues, mounting of stents on expand conveyance frameworks. [14]

CONCLUSIONS:

The assembly of these advancements will make a more vigorous supervision of coronary and vascular coronary diseases in the prospect. These advances are not sci-fi, but rather are really accessible right now and are being utilized, simply not (yet) in blend in the interventional cardiology realm. While there are prevailing as yet various obstacles to survive, apparently not long from now these advances will make our positions simpler, and render interventional and invasive care more secure for our patients.

REFERENCES:

- Mueller RL, Sanborn TA. The history of interventional cardiology: cardiac catheterisation, angioplasty, and related interventions. *Am Heart J* 1995; 129: 146–172.
- Heiss HW. Werner Forssmann: a German problem with the Nobel Prize. *Clin Cardiol* 1992; 15: 547–549.
- Schlumpf M. 30 Jahre Ballonkatheter: Andreas Grüntzig, ein Pionier in Zürich. *Schweiz Ärztezeit* 2004; 85: 3460.
- Meier P, Timmis A. Almanac 2012: interventional cardiology. *Anadolu Kardiyol Derg.* 2013 Feb;13(1):91-101. doi: 10.5152/akd.2013.049. Epub 2012 Dec 18. PMID: 23248052.
- Tobis JM, Abudayyeh I. New devices and technology in interventional cardiology. *J Cardiol.* 2015 Jan;65(1):5-16. doi: 10.1016/j.jcc.2014.08.001. Epub 2014 Sep 16. PMID: 25241014.
- Sigwart U, et al. Intravascular stents to prevent occlusion and restenosis after transluminal angioplasty. *N Engl J Med* 1995; 316: 701–706.
- Windecker S, et al. 2014 ESC/EACTS Guidelines on myocardial revascularisation: The Task Force on Myocardial Revascularisation of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS) Developed with the special contribution of the European Association of Percutaneous Cardiovascular Interventions (EAPCI). *Eur Heart J* 2014; Epub ahead of print.
- Iakovou I, et al. Incidence, predictors, and outcome of thrombosis after successful implantation of drug-eluting stents. *J Am Med Assoc* 2005; 293: 2126–2130. Mauri L, et al. Stent thrombosis in randomized clinical trials of drug-eluting stents. *N Engl J Med* 2007; 356: 1020–1029.
- Zablah JE, Morgan GJ. Innovations in Congenital Interventional Cardiology. *Pediatr Clin North Am.* 2020 Oct;67(5):973-993. doi: 10.1016/j.pcl.2020.06.012. Epub 2020 Aug 10. PMID: 32888693.
- Hokken TW, Ribeiro JM, De Jaegere PP, Van Mieghem NM. Precision Medicine in Interventional Cardiology. *Interv Cardiol.* 2020 Apr 23;15:e03. doi: 10.15420/icr.2019.23. PMID: 32382319; PMCID: PMC7203877.
- Jabbour RJ, Latib A. The changing landscape of interventional cardiology. *Aging (Albany NY).* 2019 May 29;11(10):2914-2915. doi: 10.18632/aging.102005. PMID: 31141789; PMCID: PMC6555454.
- Arbab-Zadeh A, Carli MF, Cerci R, George RT, Chen MY, Dewey M, et al. Accuracy of Computed Tomographic Angiography and Single-Photon Emission Computed Tomography Acquired Myocardial Perfusion Imaging for the Diagnosis of Coronary Artery Disease. *Circulation Cardiovascular imaging.* 2015;8(10). Epub 2015/10/16.
- Thompson AG, Raju R, Blanke P, Yang TH, Mancini GB, Budoff MJ, et al. Diagnostic accuracy and discrimination of ischemia by fractional flow reserve CT using a clinical use rule: results from the Determination of Fractional Flow Reserve by Anatomic Computed Tomographic Angiography study. *Journal of cardiovascular computed tomography.* 2015;9(2):120-8. Epub 2015/03/31.
- Gallagher AG, Renkin J, Buyl H, Lambert H, Marco J. Development and construct validation of performance metrics for multivessel coronary interventions on the VIST virtual reality simulator at PCR2005. *EuroIntervention : journal of EuroPCR in collaboration with the Working Group on Interventional Cardiology of the European Society of Cardiology.* 2006;2(1):101-6. Epub 2006/05/01.
- Jensen UJ, Jensen J, Ahlberg G, Tornvall P. Virtual reality training in coronary angiography and its transfer effect to real life catheterisation lab. *EuroIntervention : journal of EuroPCR in collaboration with the Working Group on Interventional Cardiology of the European Society of Cardiology.* 2015;11(2). Epub 2015/11/09.
- Park JW, Choi J, Park Y, Sun K. Haptic virtual fixture for robotic cardiac catheter navigation. *Artificial organs.* 2011;35(11):1127-31. Epub 2011/10/26.
- Yang de L, Xu QW, Che XM, Wu JS, Sun B. Clinical evaluation and follow-up outcome of presurgical plan by Dextroscope: a prospective controlled study in patients with skull base

- tumors. *Surgical neurology*. 2009;72(6):682-9; discussion 9. Epub 2009/10/24.
18. Davis GR, Illig KA, Yang G, Nguyen TH, Shames ML. An approach to EVAR simulation using patient specific modeling. *Annals of vascular surgery*. 2014;28(7):1769-74. Epub 2014/06/10.
 19. Mottl-Link S, Hubler M, Kuhne T, Rietdorf U, Krueger JJ, Schnackenburg B, et al. Physical models aiding in complex congenital heart surgery. *The Annals of thoracic surgery*. 2008;86(1):273-7. Epub 2008/06/25.
 20. Wang H, Liu J, Zheng X, Rong X, Peng H, Silber-Li Z, et al. Three-dimensional virtual surgery models for percutaneous coronary intervention (PCI) optimization strategies. *Scientific reports*. 2015;5:10945. Epub 2015/06/05.
 21. Holmes DR Jr, Alkhouli M. Past, Present, and Future of Interventional Cardiology. *J Am Coll Cardiol*. 2020 Jun 2;75(21):2738-2743. doi: 10.1016/j.jacc.2020.03.066. PMID: 32466890.