

Review

A Review of Advances in the Surgical Treatment of Coronary Heart Disease and Lung Cancer

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Abstract

Lung cancer is currently the most prevalent and fatal malignant tumor in China. Additionally, the incidence of coronary heart disease is steadily increasing. Both diseases exhibit a higher risk of mortality with age, particularly among elderly patients. Moreover, these diseases are interconnected and share common risk factors. However, the treatment options for patients suffering from both lung cancer and coronary heart disease lack clarity and standardized criteria. This article critically examines the literature on surgical interventions for patients with lung cancer complicated by coronary artery disease during the period from January 2021 to December 2022. It summarizes the safety and effectiveness of these interventions and highlights the various surgical options available for different patient profiles.

Keywords

coronary heart disease; lung cancer; surgical treatment

Introduction to CABG, PCI, and Lung Cancer Resection

According to the data in the 2019 China Health Statistics Yearbook report, the mortality rate for lung cancer was 49.15 per 100,000 urban residents in 2018, while the mortality rate for coronary heart disease was 120.18 per 100,000 people. The prevalence of coronary heart disease is also increasing annually. Both diseases have a higher risk of death with advancing age, particularly among individuals over 80 years old [1–3]. The combined incidence of lung cancer and coronary heart disease is on the rise, with lung cancer patients being more susceptible to developing coronary heart disease. Additionally, the presence of coronary heart disease can impact the prognosis of lung cancer patients. These two diseases often coexist in middle-aged and elderly individuals [4–7]. They share common risk factors such as smoking, obesity, dietary habits, hormone levels, and lifestyle [8,9]. Common treatments for coronary heart disease include CABG (Coronary Artery Bypass Grafting) and PCI (Percutaneous Coronary Intervention).

PCI refers to the placement of a metallic stent at the location of a coronary artery lesion, with the aim of providing vascular wall support through balloon expansion. This procedure effectively maintains arterial patency, prevents the occurrence of local inflammatory response, thrombosis, or blockage resulting from excessive lining hyperplasia [10].

On-pump CABG involves distal vascular anastomosis using a cardiopulmonary bypass machine while the heart is in cardiac arrest. This technique offers a clearer surgical field of vision, facilitating easier exposure of the coronary artery. Extracorporeal circulation ensures more comprehensive blood circulation reconstruction [11]. Moreover, on-pump CABG simplifies the procedure and requires a shorter learning period, making it easily adoptable by clinicians [12].

In contrast, off-pump coronary artery bypass grafting (OPCABG) is usually performed on a non-beating heart. This technique significantly reduces the risks of cancer spread, intraoperative bleeding, systemic inflammatory response syndrome (SIRS), and pulmonary edema. Consequently, OPCABG effectively minimizes mortality and the incidence of complications [13]. As a result, OPCABG is increasingly becoming a preferred surgical approach for coronary artery bypass grafting.

The surgical management of coronary heart disease in patients with lung cancer primarily involves three approaches: (1) staged PCI followed by lung cancer resection; (2) two-stage CABG followed by lung cancer resection; (3) simultaneous CABG and lung cancer resection, which encompasses both on-pump CABG and off-pump CABG. Previous studies have indicated a higher postoperative mortality risk for patients who undergo PCI prior to lung cancer surgery compared to those in the non-PCI group [14]. Performing surgery in two stages can result in two wounds and increase pain and pressure on patients. Among these three approaches, simultaneous CABG combined with pneumonectomy is widely considered both feasible and effective [15], although certain studies have highlighted a higher risk of postoperative complications with combined surgery [16]. Therefore, the selection of the appropriate surgical approach should be based on the individual needs of the patients.

Compared to the general population, patients undergoing PCI after lung cancer resection experience a progressively higher incidence of death, stroke, and myocardial infarction over time [17,18]. Additionally, the frequency of stent-related complications also increases over time. Discontinuation of antiplatelet therapy following PCI is associated with major adverse cardiovascular events (MACE) and other complications after lung cancer resection. On the other hand, resuming antiplatelet therapy after PCI may elevate the risk of bleeding. While the risk of cancer-related mortality decreases over time following surgery, the risk of cardiovascular disease-related mortality increases [19–21]. Performing lung cancer resection after PCI can reduce the occurrence of adverse events, such as myocardial infarction, during the perioperative period of lung cancer surgery. Nonetheless, since PCI patients require dual antiplatelet therapy (DAPT) and subsequent cessation of DAPT, there is a heightened susceptibility to stent thrombosis. To ensure patient safety, it is advisable to delay additional tumor treatment for several months after PCI [22]. There is currently no standardized protocol for the optimal timing of tumor treatment surgery. P.G. Chassot recommended a minimum delay of 3 months between PCI and pneumonectomy, allowing for the completion of the 6-week high-risk period and the 3-month medium-risk period. This delay ensures full endothelialization of the stent surface. However, it is important to note that lung cancer may progress and worsen during this 3-month period [23–26]. According to the guidelines provided by the American College of Cardiology/American Heart Association (ACC/AHA), patients can undergo lung cancer resection 30 days after the implantation of a bare metal stent (BMS) [27]. However, if a drug-eluting stent (DES) is used, it is recommended to delay lung cancer surgery for 365 days to avoid stress reactions during the perioperative period, which could lead to intravascular thrombosis. In emergency situations, when the risk of delaying surgery outweighs the risk of ischemia and thrombosis, the waiting period can be shortened to 180 days after careful assessment [27–30]. Fernandez *et al.* [19] demonstrated that stent placement within 12 months before pneumonectomy increased the occurrence of MACE and mortality within the first 30 days after surgery. Additionally, it heightened the risk of perioperative thrombosis and myocardial infarction. In light of these findings, Marcucci *et al.* [31] recommend prioritizing balloon dilation over stenting for preoperative revascularization, with PCI performed after the patient has sufficiently recovered from lung cancer surgery. The 2022 PCI consensus of the Japanese Association for Cardiovascular Intervention (CVIT) also supports this approach, explaining that it helps avoid exacerbating the risk of reinfarction or ischemia associated with stent implantation [32,33]. If vascular reconstruction is accomplished using balloons rather than stents prior to lung cancer

surgery, the minimum interval between the two procedures should be 14 days [27].

Coronary Artery Bypass Grafting and Lung Cancer Resection by Stages

Staged surgery, which involves two separate surgeries for CABG and lung cancer resection, presents certain drawbacks in terms of patient outcomes, healthcare costs, and overall treatment efficiency. This approach necessitates the administration of two general anesthetics and results in two surgical incisions, thereby increasing the length of hospital stay. Consequently, patients experience heightened levels of preoperative pressure and postoperative pain, leading to an overall increase in treatment expenses. Moreover, staged surgery is associated with various complications arising from multiple anesthesia administrations, potential disease progression due to delayed treatment, patient anxiety, elevated treatment costs, and prolonged hospitalization [34]. In cases where staged surgery is deemed necessary, it is generally recommended to prioritize cardiac surgery before pulmonary surgery. To ensure the efficacy of anticoagulation, it is advised to perform pulmonary surgery within 3–6 weeks following cardiac surgery [35–37]. According to the clinical conditions of individual patients, the surgery interval should be personalized. When patients are in a favorable condition, the interval can be appropriately shortened, with the recommended minimum interval being 1–2 weeks [38,39]. However, due to the demanding nature of the staged operation method, which involves two separate surgeries, increased psychological pressure, and an extended hospital stay, it is challenging to persuade patients to undergo another surgery within a relatively short timeframe. Conversely, simultaneous treatment of both diseases can eliminate the need for a second operation, reduce perioperative pressure and discomfort, and yield economic benefits by minimizing treatment and hospitalization costs. In comparison to staged surgery, concurrent surgery offers potential advantages such as a single anesthesia induction, reduced psychological pressure, shorter overall hospital stays, lowered treatment costs, and no delay in lung cancer treatment. Nonetheless, concurrent surgery carries a higher risk of perioperative mortality and complications compared to staged surgery, and presents technical difficulties in exposing both lungs and removing mediastinal lymph nodes. Therefore, the selection of surgical methods should be determined based on the patient's condition and requirements.

Concurrent Coronary Artery Bypass Grafting Combined with Lung Cancer Resection

Combined surgery refers to the simultaneous performance of cardiac surgery and pulmonary surgery. Patients who exhibit unstable symptoms of coronary artery disease, inadequate response to medication, or have experienced failure or infeasibility of PCI may opt for combined surgery.

In contrast to staged surgery, combined surgery employs one or two surgical incisions under general anesthesia, effectively avoiding delays in lung cancer treatment and minimizing the risks associated with undergoing multiple operations. Existing studies have indicated a higher incidence of postoperative complications in simultaneous surgery compared to staged surgery. However, the difference in long-term survival between the two approaches is not statistically significant. Therefore, it is widely accepted that combined surgery is the appropriate procedure for certain patient populations and is considered safe for both younger and older patients [40–46]. It is recommended to select either staging or combined surgery based on a comprehensive personalized evaluation of patients in advance [16]. Coronary artery bypass grafting encompasses on-pump CABG and OPCABG.

Adverse Reactions of On-Pump CABG

On-pump CABG is an effective treatment for coronary heart disease. However, the use of cardiopulmonary bypass (CPB) can also give rise to various adverse reactions. CPB has been found to elevate levels of interleukin-10 (IL-10) and transforming growth factor- β (TGF- β). These cytokines possess immunosuppressive properties, potentially promoting tumor growth and metastasis. Performing lung tumor resection under cardiopulmonary bypass may facilitate the dissemination of tumor cells throughout the body. Additionally, CPB can result in incomplete neutralization of heparin overdose by Cichlidin sulfate, as well as platelet dysfunction, leading to hemorrhage [47]. CPB is associated with numerous side effects. It can increase the permeability of pulmonary capillaries, leading to pulmonary edema. Additionally, it can cause an imbalance in the ventilation-perfusion ratio, resulting in postoperative hypoxemia. CPB has also been linked to multiple organ dysfunction, including dysfunction of the brain, lungs, and kidneys. It may induce respiratory symptoms such as acute respiratory distress syndrome. Moreover, CPB can inhibit lymphocytes, neutrophils, polymorphonuclear cells, and natural killer cells, thereby compromising the body's immune response and triggering SIRS [41,48–57]. Studies have demonstrated that compared to patients not subjected to CPB, those undergoing CPB have a significantly higher incidence of cerebral vascular embolism. Furthermore, in the short term (less than 2–3 months), these patients experience greater neurocognitive decline [58].

Advantages of OPCABG Selection

The poor prognosis following CABG is attributed to endothelial activation and systemic inflammatory reactions during the perioperative period. These phenomena can be mitigated by utilizing OPCABG [59]. When considering the bleeding risk associated with combined surgery, lung cancer resection alone does not significantly increase

the risk of thoracic bleeding during cardiovascular surgery. However, when CPB is combined with pneumonectomy, surgical bleeding becomes more pronounced, potentially leading to respiratory failure. OPCABG procedures can reduce systemic blood coagulation disorders and minimize bleeding in areas relevant to lung surgery. However, they may also introduce additional complications, such as mediastinitis, postoperative bleeding necessitating reoperation, perioperative tension pneumothorax, early postoperative acute respiratory distress syndrome, arrhythmia, and others [13,60–63].

Indications for Simultaneous Operation

According to the scholarly paper, the suggested criteria for concurrent procedures indicate that patients with operable non-small cell lung cancer (ranging from stage IA to stage IIIA, stage N0 or N1) are considered suitable candidates. Additionally, these patients should not have a recent history of myocardial cancer infiltration but should have a history of myocardial infarction, PCI failure, or infeasible unstable angina. For patients, particularly those unable to undergo a second operation, the combined procedure is deemed secure, yielding positive outcomes and a favorable prognosis [14,42,64–66].

In patients diagnosed with stage N2, where the long-term efficacy of surgical treatment is generally unsatisfactory, it is advised to avoid surgery and prioritize neoadjuvant chemotherapy to prevent metastasis and minimize the burden of a subsequent operation. If concurrent surgery is deemed necessary, caution should be exercised when dealing with the internal mammary artery (IMA), and it is crucial to use saphenous vein grafts with adequate blood flow, particularly in patients with poorly differentiated lung cancer [36,65]. Furthermore, certain patient profiles are not suitable for concurrent surgery, including those with (1) tumors in close proximity to the descending aorta or esophagus; (2) concomitant tumors in other organs (e.g., esophagus) or tumors encroaching on the pleura or diaphragm wall; (3) extensive and severe chest adhesions; (4) indications for complex total pneumonectomy; (5) heart failure necessitating high doses of catecholamines; and (6) patients with hemodynamic instability and a propensity for severe hemorrhage [61,67–70].

Indications of On-Dump CABG

The advantages of on-pump CABG over OPCABG can be summarized as follows: (1) On-pump CABG leads to a more thorough vascular regeneration process, resulting in improved integrity of myocardial hemotransfusion reconstruction. (2) The use of extracorporeal circulation allows for a better surgical field of view, facilitating the creation of distal anastomoses. (3) On-pump CABG is a preferred choice in emergency situations. (4) OPCABG,

on the other hand, places a lower cardiac load on ischemic hearts and has higher rates of hemotransfusion reconstruction. Therefore, the use of extracorporeal circulation in CABG becomes more justifiable during emergencies. (5) The utilization of extracorporeal CABG has demonstrated a reduction in angina recurrence rates and a decrease in re-hospitalization frequency. Thus, on-pump CABG is a more reasonable approach.

Furthermore, a study conducted by Darwazah *et al.* [71] confirms that the use of cardiopulmonary bypass during emergencies reduces the rate of angina recurrence, alleviates symptoms of heart failure, and decreases the frequency of rehospitalization [72].

Indications of OPCABG

When comparing the selection between on-pump CABG and OPCABG, opting for OPCABG offers several distinct advantages by eliminating the need for CPB: (1) Compared to conventional CABG, OPCABG offers a significant reduction in surgical mortality and postoperative complication rates. (2) OPCABG has demonstrated the potential to ameliorate blood coagulation disorders, thereby reducing the likelihood of reoperation, intraoperative bleeding, and the need for blood transfusions. (3) OPCABG holds promise in safeguarding patients against potential nervous system complications, including stroke or coma. (4) To ameliorate the immunosuppressive effects of CPB on the body and mitigate SIRS. (5) Patients who undergo OPCABG experience significant reductions in the duration of mechanical ventilation, postoperative hospital stay, length of stay in the intensive care unit (ICU), incidence of perioperative myocardial infarction, and occurrence of new atrial fibrillation. (6) To minimize the risk of cancer metastasis, it is recommended to avoid the utilization of CPB. (7) Decrease the occurrence of pulmonary insufficiency, pulmonary failure, renal failure, and multiple organ failure. (8) Minimize the necessity of utilizing an intra-aortic balloon pump (IABP) during the perioperative period. (9) Reduce the hospitalization costs [13,41,63,73–75]. (10) In elderly patients, the On-pump CABG group demonstrates higher rates of bleeding, blood transfusion, stroke, prolonged respiratory failure, as well as increased durations of ICU and hospital stay compared to the OPCABG group. These findings suggest that OPCABG surgery may offer greater benefits for elderly patients [76,77]. (11) In patients with severe atherosclerosis, the use of CPB is associated with higher incidence of stroke and mortality. On the other hand, OPCABG has shown to be effective in reducing complications, stroke, and hospital mortality in these patients. Therefore, OPCABG may be a preferable surgical approach for patients with severe atherosclerosis [78,79]. (12) According to studies, the mortality rate among female patients undergoing on-pump CABG is higher compared to male patients. However, this risk can be mitigated by avoid-

ing the use of CPB. As a result, OPCABG may be more beneficial for female patients. (13) Research has shown that on-pump CABG is associated with the formation of more cerebral microemboli, which can lead to reduced cerebral perfusion in various regions of the brain, including the thalamus, cerebellum, anterior cuneiform lobe, bilateral occipital region, and left temporal lobe after surgery. In contrast, OPCABG has been found to result in almost unchanged cerebral perfusion compared to on-pump CABG. OPCABG has also been shown to significantly reduce the likelihood of brain microemboli formation when compared to on-pump CABG. This suggests that OPCABG may be a preferable surgical approach to mitigate the risk of cerebral complications and preserve cerebral perfusion, potentially leading to improved neurological outcomes for patients undergoing CABG surgery. (14) Patients with multiple comorbidity factors before surgery are indeed considered high-risk patients. These risk factors include a recent history of myocardial infarction, left ventricular dysfunction, left main disease, multiple organ failure, previous stroke, shock, unstable angina pectoris, heart failure, female gender, ejection fraction <0.5, IABP, New York Heart Association (NYHA) class IV cardiac function, three-vessel disease, chronic obstructive pulmonary disease, elderly patients, or emergency surgery [80–87]. In the surgical selection of high-risk patients with multiple complications, OPCABG has been found to have lower mortality and incidence rates compared to other surgical approaches. Therefore, OPCABG can be considered a reasonable and feasible surgical strategy for patients with these high-risk factors. (15) For patients with acute myocardial infarction, research suggests that the mortality rate is significantly higher in the on-pump CABG group compared to the OPCABG group. However, it is important to note that most of the deaths in the on-pump CABG group occurred within 2 days of the myocardial infarction. On the other hand, there was no significant difference in mortality among patients who underwent surgery more than 2 days after the myocardial infarction. Based on this information, it can be concluded that OPCABG is more beneficial for emergency patients who undergo surgery within the first 2 days of experiencing symptoms of myocardial infarction [88].

Operation Sequence

According to the literature, there exists a general consensus regarding the optimal surgical sequence involving OPCABG and lung cancer resection. This sequence is primarily based on two key reasons: Firstly, to mitigate any potential complications during the lung cancer resection procedure, it is essential to guarantee a sufficient supply of blood to the myocardium. Consequently, it is recommended that OPCABG be conducted prior to lung cancer resection [63,89]. Secondly, the incisions made during CABG surgery (referred to as type 1 incisions) and lung

cancer resection (known as type 2 incisions) differ in nature. Opening the pleura during the latter procedure may compromise the sterile environment of the mediastinum. Given the grave consequences associated with chest infections, maintaining strict sterility during surgical operations becomes imperative. Therefore, it is crucial to prioritize bypass surgery before proceeding with radical lung cancer surgery [4].

Surgical Approach

Median sternotomy is the preferred surgical approach for heart procedures, particularly in cases of right pneumonectomy and left upper lobe pneumonectomy. Research conducted by Urschel and Razzuk [34] demonstrated that patients who underwent lung cancer resection via median sternotomy experienced several advantages over those who underwent lateral thoracotomy, including reduced operation time, postoperative pain, complications, and hospital stay [4,90]. Furthermore, median sternotomy facilitates the creation of bronchial stumps, minimizes pulmonary dysfunction, and exhibits high tolerance [91]. This approach is highly effective in accessing the upper mediastinal lymph nodes, particularly the lower carina lymph nodes. Additionally, compared to standard thoracotomy, median sternotomy enables a more thorough dissection of bilateral para-esophageal lymph nodes. However, it should be noted that median sternotomy offers limited visual field assistance during lung cancer resection. In the case of left pneumonectomy and left lower lobectomy, a simple median sternotomy is not the conventional approach due to the obscured intraoperative view caused by the heart. Cardiac retraction is often necessary, but it can result in arrhythmias, hemodynamic instability, and technical challenges [61]. Alternatively, a standard left anterolateral thoracotomy can be safely combined with bypass surgery [54]. However, this technique limits the surgeon to establishing a distal anastomosis solely on the side of the heart where the left anterior descending branch is located. While combining a double incision with a left anterolateral open thoracotomy and a median sternotomy is an option, it is associated with postoperative complications such as pulmonary atelectasis and infection. Hence, most surgeons prefer performing simultaneous surgery through a single incision. However, when a single incision is deemed insufficient for the procedure, it is feasible to add a lateral thoracotomy to the median sternotomy or extend the median sternotomy into the intercostal space [41,61,89,92]. Intraoperative care should prioritize protecting the myocardial bridge, minimizing compression and traction on the cardiopulmonary tissues, and attending to the relationship between the pulmonary artery and the bronchi to avoid accidental injury [93]. In various aspects such as hospital stay, postoperative pain, retention of lung function, and postoperative complications, thoracoscopic lung cancer resection demonstrates superiority over

thoracotomy. As a result, it can be considered a feasible and effective surgical approach [94,95]. However, the existing research on the simultaneous operation of CABG combined with thoracoscopic lung cancer resection remains incomplete, and further investigation is warranted to determine the optimal choice between thoracoscopy and thoracotomy for combined surgery.

Scope of Lymph Node Dissection

Lymph node dissection is a crucial component in accurately staging lung cancer and improving postoperative survival rates. However, there exists a significant controversy regarding the extent of lymph node dissection. While thorough systematic lymph node dissection is generally deemed beneficial, some studies question the survival advantage compared to more limited dissection [14]. Furthermore, systematic lymph node dissection prolongs operation time and increases the postoperative incidence rate [96]. Therefore, although systematic lymph node dissection is recommended, selective lymph node dissection is also regarded as an acceptable choice for lung cancer surgery, particularly for stage 1 and stage 2 tumors, as it effectively clears the tumor. Selective lymph node dissection offers the advantage of reducing hospital stays, but its reliability and applicability remain uncertain [97,98].

Evaluation of Postoperative Survival of Patients

Yoon's [14] research has demonstrated the utmost importance of accurately assessing pathological staging and conducting preoperative evaluations in patients. Common causes of mortality following combined surgery include distant metastasis and local recurrence of tumors, both of which significantly impact long-term survival rates in postoperative patients [99,100]. Conversely, the progression of heart disease does not pose a risk factor for postoperative mortality or incidence rates [101]. Therefore, a thorough preoperative evaluation of factors potentially affecting postoperative outcomes is crucial in determining whether combined surgery or staged surgery should be performed. These factors can be categorized as preoperative predictors, such as gender, age, presence of chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), kidney disease, any tumor diagnosis within five years prior to lung cancer surgery, and the clinical stage of the tumor. Additionally, postoperative predictors, including the type of resection and pathological stage of lung cancer, serve as more precise indicators of long-term survival rates following surgery [45,102].

Postoperative Management of Patients

Following lung cancer resection, patients experience diminished cardiopulmonary function, impeding the physiological recovery of the lungs and elevating the risk of

respiratory complications. Moreover, patients with multiple comorbidities such as diabetes mellitus, renal failure, and hyperglycemia face additional challenges during recovery, necessitating preoperative interventions to mitigate severe postoperative complications [93,99]. Increased levels of cytokines including TNF- α , IL-6, and IL-10 have been observed in patients with coronary artery disease, and the use of high tidal volume (Vt) mechanical ventilation after lung cancer surgery can result in cytokine-mediated pneumonitis. Therefore, postoperative patients should receive ventilation with a reduced Vt and positive end-expiratory pressure (PEEP) to minimize the duration of mechanical ventilation, thereby preventing lung injury and reducing the risk of infection [103]. Excessive fluid infusion during the perioperative period may lead to postoperative pulmonary edema and other pulmonary injuries. Hence, the intraoperative infusion rate should not exceed 7–8 mL/kg/h, and the postoperative infusion rate should not exceed 1–2 mL/kg/h. Additionally, maintaining a positive fluid balance of no more than 1.5 liters per day can effectively reduce the incidence of postoperative complications [104]. In younger patients (≤ 70 years) and older patients (≥ 70 years), postoperative morbidity is influenced differently. In younger patients, morbidity is notably associated with histological cell type and extent of lung resection, whereas in older patients, it is also related to hypertension, elevated serum creatinine levels, reduced DLCO (diffusing capacity of the lungs for carbon monoxide), and smoking [105]. Hence, managing the elderly population requires meticulous care to minimize postoperative morbidity.

Problems Still Faced

It was hypothesized that OPCABG would eliminate the adverse effects of CPB, resulting in improved survival rates and reduced complications. However, several studies have indicated that hospital survival is not significantly influenced by factors such as age, gender, cardiac or pulmonary pathology, or the utilization of CPB. While it was initially thought that the use of cardiopulmonary bypass increased the occurrence of ischemic brain injury, numerous studies have failed to demonstrate that extracorporeal circulation is superior to CPB in preventing brain damage. Therefore, the anticipated association between CPB and hospital survival remains unconfirmed, necessitating further investigation [106,107].

Summary

In recent years, there has been an increasing number of patients diagnosed with both lung cancer and coronary heart disease. However, a standardized approach for managing these two coexisting conditions is yet to be established. This article aims to summarize and compare vari-

ous surgical methods available for patients with lung cancer and coronary heart disease, including their respective advantages and disadvantages.

Simultaneous cardiopulmonary surgery carries the risk of intraoperative bleeding due to anticoagulation therapy. Staged surgery, on the other hand, offers the benefit of reducing postoperative mortality and perioperative complications. However, it has the drawback of subjecting patients to additional trauma and economic burden, as well as an increased risk of lung cancer progression during the interval between operations. Currently, combined procedures such as on-pump CABG and OPCABG combined with lung cancer resection are widely performed. The decision to use CPB during surgery depends on the patient's condition and specific requirements.

The advantage of CPB lies in its ability to ensure complete reconstruction of myocardial blood supply and provide a broader surgical field, facilitating distal vascular anastomosis. It is particularly suitable for emergency cases and relatively straightforward to perform. However, the use of CPB is associated with SIRS, multiple organ failure, increased bleeding, and potential promotion of tumor growth and metastasis, among other complications.

By contrast, OPCABG can mitigate the inflammatory response caused by CPB, effectively avoiding these associated complications and has shown superior efficacy, especially for elderly patients, those with severe atherosclerosis, women, and high-risk patients.

In general, for patients with both coronary heart disease and lung cancer, performing cardiopulmonary surgery simultaneously is recommended if the overall condition permits. The decision regarding the use of CPB should be based on individual patient factors and needs.

Several limitations exist in this study. Firstly, variations in statistical methodology and clinical data collection among the included studies may have resulted in heterogeneity in the overall conclusions. Secondly, the majority of included studies were retrospective observational studies conducted at single centers, warranting the need for prospective studies to validate these findings. Thirdly, most of the included studies primarily focused on perioperative outcomes, with limited data available on long-term survival rates for postoperative patients. Further investigations are required to determine the impact of different surgical approaches on long-term patient survival. Lastly, the number of articles comparing combined and staged surgeries is limited, highlighting the need for additional research in this area.

Author Contributions

WL and MT contributed to the design and analysis, YH and SW contributed to the interpretation of data for the work. All authors contributed to editorial changes in

the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

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Conflict of Interest

The authors declare no conflict of interest.

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