Chapter 5

Abdominal Aortic Aneurysm and Malignancies

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Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.76811

Abstract

Concomitant AAA and abdominal malignancy are always very complicated conditions requiring early management of both pathologies. This is undoubtedly a dilemma for a surgeon who cannot currently rely on any large randomized trials or mandatory guidelines. When making decisions, a surgeon most often relies on personal experience, the experience of his/her center and/or limited literary guidelines and recommendations. Efforts should be aimed at achieving a consensual multidisciplinary decision about which pathology requires "more acute" management. The decision-making process is easier if one of the pathologies is life-threatening, and such pathology should be managed first. In most cases, however, AAA is asymptomatic and a malignancy is found randomly, as a secondary finding during the follow-up of AAA patients, or vice versa, AAA is found randomly during the staging of cancer patients. In these cases, the therapeutic algorithm already admits several possible variants. Endovascular repair of AAA (EVAR) resulted in an absolute change in the management of these patients. EVAR can be used in simultaneous or stage procedures with minimal time delay. Also, surgical open resection is an option (simultaneously or staged). It is necessary to know the advantages and risks of all approaches.

Keywords: abdominal aortic aneurysm, malignancy, single stage surgery, endovascular surgery, simultaneous treatment

1. Introduction

The incidence of abdominal aortic aneurysm (AAA) has been increasing steadily over the last 40 years [1], and according to recent literature data, it ranges from 15 to 37 cases per 100,000 population per year, while the prevalence is about 5% in men above 65 years of age [2, 3].

Although the incidence of gastrointestinal or genitourinary tract tumors differs in different parts of the world, these are some of the most common intra-abdominal malignancies.

It is therefore logical that AAA can from time to time be diagnosed concurrently with solid tumors in the abdominal cavity. The incidence of AAA and concurrent malignancy in the abdominal cavity is about 3–13% [4–6]. Some risk factors are common in the etiopathogenesis of both AAA and colorectal carcinoma or urinary tract carcinoma. Some papers even report a higher occurrence of malignant diseases in AAA patients than in patients presenting with atherosclerosis only [7].

One of the first papers to deal with the concomitant AAA and malignant tumor was published by Szilagy in 1967 [8]. Its prevalence of patients with synchronous AAA and malignant tumors was 3.9%. Of course, tremendous developments have taken place in the treatment of both AAA and malignancies over the 50 years that have elapsed since this publication. During this time, a number of authors have been involved in this issue. However, they have most frequently published case reports or "single center experience" articles describing a limited population of patients, while multicenter studies have been reported rarely [9]. Kouvelos is one of the few authors who has tried to present a larger group of patients in his meta-analysis [10]. However, we still lack a large randomized study, and the question is whether such study is feasible at all in this field. The reason is the huge heterogeneity of this population. Although clear indications criteria for AAA treatment are now widely accepted worldwide (asymptomatic over 50–55 mm, symptomatic and rupture of course), regional differences are still present in the treatment method (open repair/endovascular approach). This inconsistent 'policy' is evident both among the various countries of the world and among the various institutions in one country. If the AAA does not meet indication criteria for AAA therapy, tumor should be treated and AAA is not the issue for treatment at that time.

As mentioned above, significant changes have occurred in the surgical and endovascular treatment options since the days of Szilagy, yet the basic dilemma remains the same. Which treatment algorithm to choose? Which pathology to treat earlier? The aneurysm or the tumor? Another option is a synchronous procedure (single-stage surgery). Even after 50 years, the answer to this question cannot be clearly answered. Nevertheless, some recommendations and guidelines can be defined more clearly thanks to the development of endovascular treatment for AAA (EVAR). However, the decision about the treatment strategy for a particular patient is not always clear. The logical answer that "a more acute lesion should be treated first" may not be sufficient in certain situations. The question is whether we are always able to define which pathological finding (AAA or tumor) is more acute. A number of factors may play a role in this decision. Concerning the aneurysm, these are mainly the size, the risk of rupture, anatomy, localization, and symptoms. Concerning the tumor, such factors may include the type, localization, biological nature (grading), extent (staging), and the overall condition of the patient. Other factors may play a role, such as the potential need for further neoadjuvant or adjuvant oncological treatment (chemotherapy, radiotherapy) and, last but not least, the decision of the surgeon can be influenced by the patient's opinion, who may express some wishes that must be respected despite being a nonprofessional in this field.

Two basic extreme situations are usually beyond discussion: an AAA rupture always requires urgent management, be it a resection or endovascular treatment. Due to the urgency of the situation and the complexity of the procedure, we do not attempt to manage any tumor in the vast majority of cases. Tumor management comes later, after the convalescence of the patient. In rare cases, where AAA rupture has been managed without any circulatory problems and without major blood loss, an intra-abdominal tumor can be managed at the same time, provided that such procedure is relatively simple and uncomplicated. An ill-considered effort to manage everything at one time often leads to failure. An analogous situation may occur in confirmed generalized malignancy, which we are unable to influence by therapy, and the patient has a very limited life-expectation, thus we do not indicate any procedure even in large AAA. If rupture occurs, we can try to perform an acute procedure, but even this remains an ethical question. In the case of terminal phase of malignancy is ethical to refuse the surgery. Fortunately, these two extreme situations do not present in the vast majority of cases in patients with concomitant AAA and abdominal cavity tumor. More frequently, the patient is diagnosed with AAA during CT scanning for intra-abdominal tumor staging, or vice versa, a patient followed-up for AAA can be diagnosed with a malignancy during regular check-ups.

Then the crucial decision comes… "what first? … or simultaneously?" It is necessary to know the advantages and risks of the respective approaches. With the "tumor first" approach, the patient gets the benefit of early elimination of the malignancy with a lower risk of local progression and distant spreading, but at the cost of a certain risk of rupture in the postoperative period. An increased risk of AAA rupture after laparotomy has been repeatedly published in the literature, whether due to changes in the abdominal cavity, local irritation of AAA, but also due to collagenolysis caused by postoperative stress and nutritional depletion [11–13]. Subsequent chemotherapy may also have an effect on AAA [14], according to some authors. When choosing the "AAA first" approach, we delay the removal of the malignant tumor with its potential consequences. In this situation, however, it is absolutely crucial what type of AAA treatment we choose. Mini-invasive EVAR, which is preferred in this case, will minimally delay the tumor resection, the convalescence is very short, usually several days, and the subsequent procedure can be performed very soon. However, we are not always in a position to choose EVAR, either due to the AAA anatomy (angulation and neck length, tortuosity or calcification of the iliac arteries), or purely for logistical reasons, such as the inability to obtain the required stent-graft in time (in particular for juxtarenal or pararenal AAAs). In these cases, we choose a resection method of treatment, which certainly leads to a significant delay in tumor treatment. Similarly, operational stress and the subsequent catabolic phase can lead to progression of the malignancy. Finally, in the selected group of patients, a third option, single-stage surgery, can be chosen, and EVAR or AAA resection is performed together with tumor resection. The main risk is the possibility of graft infection, which differs in different types of tumor (colorectal/kidney/liver).

As mentioned above, the development of endovascular repair has played a major role in choosing a strategy for the treatment of concomitant tumors of the abdominal cavity and AAA in recent decades. Multiple debates have been going on around the world about the benefits and disadvantages of open repair versus EVAR. A number of studies have been conducted, usually with expected conclusions in the short-term follow-up but already slightly

controversial within the long-term: EVAR 1, EVAR 2, DREAM, OVER [15–18]. However, the presented results are "aging" very quickly given the continuing development of stent-grafts, with their latest generations promising, in particular, better long-term results. Yet, in the short-term, EVAR, of course, reduces perioperative morbidity, reduces the need for blood transfusions, and reduces hospitalization. Similarly, there has been good development in the surgical treatment of abdominal cavity tumors. More and more procedures can be minimally invasive using laparoscopy or robotics, thereby reducing perioperative stress and burden for the patient, especially when choosing a synchronous procedure or the "tumor first" strategy [19, 20].

If the EVAR approach was chosen, we have to consider with later postoperative follow-up. CT angiography is still gold standard but less invasive procedures as a contrast ultrasound or even regular ultrasound are often sufficient. Periodically CTA examinations can also serve as a dispenzarisation after malignancy resection.

Knowing the above information, we can now discuss the individual types of malignancy and outline the treatment options. The authors present their own experience obtained at a university clinic, which is a high-volume center for both AAA treatment and the treatment of a complete range of malignancies. Their experiences are confronted with literary data. The presented recommendations can be seen as personal experience, supplemented by guidelines generally accepted in the scientific literature.

We need perfect diagnostic backgrounds to make a precise and rational decision regarding treatment strategy. Knowledge of the size and anatomy of AAA, the local extent of the tumor, its resectability, and staging are the key information we need to know before any surgical procedure.

2. Diagnosis

Ultrasound is often the first tool to reveal the diagnosis of intra-abdominal malignancies and AAA. This can include screening tests in completely asymptomatic patients or primary imaging used to evaluate the patient's symptoms. Later, however, it is always supplemented by more precise techniques to better assess the specific situation. As part of the diagnosis of abdominal aortic involvement, computer tomography (CT angiography, CTA) is the method of first choice, which precisely determines the extent of aneurysmal dilation, maximum dimension of the aneurysm, character of the aortic wall, involvement of the visceral branches, presence of thrombus, etc. CT scanning is able to reveal with high sensitivity and specificity an aneurysmal rupture which may sometimes be "covered" in the first stage and does not form a typical hematoma in the retroperitoneum. Certainly, there have been efforts to identify "high-risk" aneurysms that are at high risk of rapid progression and rupture. To date, only absolute dimension and rate of AAA progression have been demonstrated to be significant factors. Continued efforts have been made to find a marker on CTA which would indicate an imminent risk of rupture. A number of research facilities have participated in the development of software that works with biomechanical analysis and AAA modeling to evaluate the pressure on the

aneurysm wall, high-risk sites, the role of intraluminal thrombus, etc. [21–24]. Commercially available software is now available that aims to predict rupture based on information obtained from CTA. However, the research in this field is still to a certain extent experimental, and no extensive studies have been conducted to confirm the benefits of this method for common diagnosis in clinical practice. In a slightly different way, research is underway to predict rupture based on ECG-triggered CT angiography, a condition where software evaluates AAA behavior during pulse-wave analysis. A number of studies are already available in this field, confirming that analysis of aortic wall distensibility can reveal a high-risk AAA [25, 26]. Despite all this research, it is not yet possible to reliably distinguish a stable aneurysm, which remains unchanged or undergoes minimal progression only over a long period of time, from aneurysms at high risk of rupture even despite having a smaller dimension. CTA is often used as the premier method for the diagnosis of tumors of the liver (requiring multiphase examination), and kidneys, and often also for evaluating the staging of all malignant tumors in the abdominal cavity, including stomach or colorectal tumors (**Figure 1**).

Digital subtraction angiography (DSA) is only minimally used in the diagnosis of AAA, and can be used in cancer surgery for the visualization and occlusion of vessels nourishing the malignant tumor within a specific preoperative preparation.

Magnetic resonance imaging (MRI) may be added, especially in liver tumors, but also in tumors of the retroperitoneum or soft tissue tumors. MRI combined with contrast-enhanced ultrasound (CEUS) or with CT safely differentiates malignant liver tumors from benign lesions (focal nodular hyperplasia, hemangioma, and adenoma). In this way, we can obtain key information to decide whether the tumor management can be postponed or acute treatment is needed.

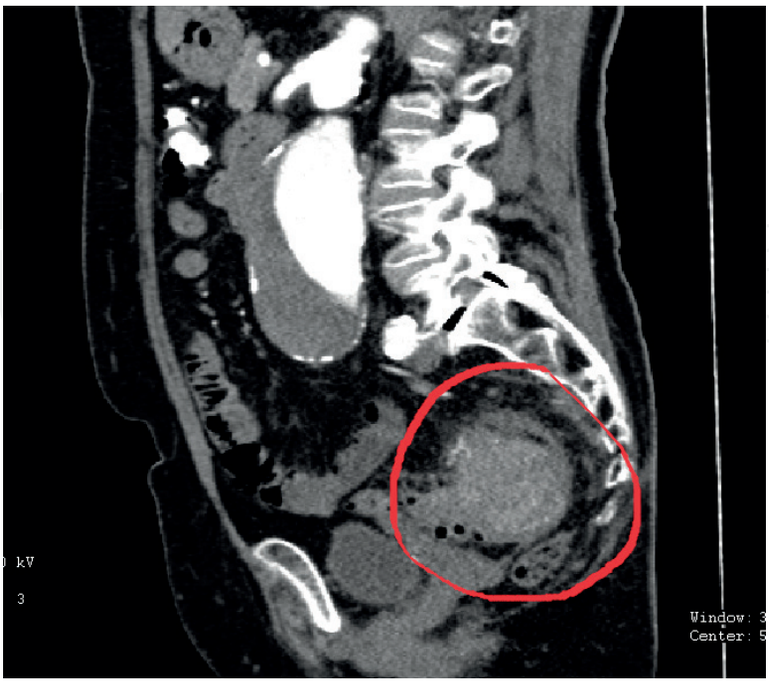

Figure 1. AAA and rectosigmoid tumor (CTA).

In recent years, hybrid methods have also been added to the diagnostic portfolio, such as positron emission tomography and CT (PET CT), positron emission magnetic resonance imaging (PET MRI). These methods, which are commonly used for the diagnosis of malignancies, or their staging or follow-up, may also sufficiently reveal the presence of any pathology on the abdominal aorta, including AAA (**Figures 2–5**). In some cases, it may also raise the suspicion of an inflammatory etiology of AAA, and its increased risk [27, 28]. These methods are able to reveal the extent of the malignancy with high sensitivity.

Endoscopic examination, whether esophagogastroscopy or colonoscopy, is always included in the diagnosis of stomach, duodenal and colorectal tumors. Occasional concerns of gastroenterologists about the use of these endoscopic techniques in patients with a large AAA are not based on any valid literary data. Classical colonoscopy can sometimes be replaced with virtual CT colonography [29].

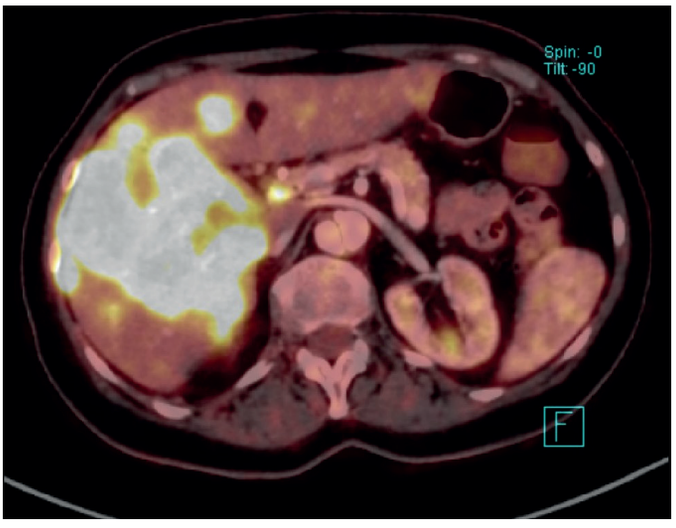

Figure 2. Multiple metastases of colorectal carcinoma in the liver and aortic dissection (PET CT).

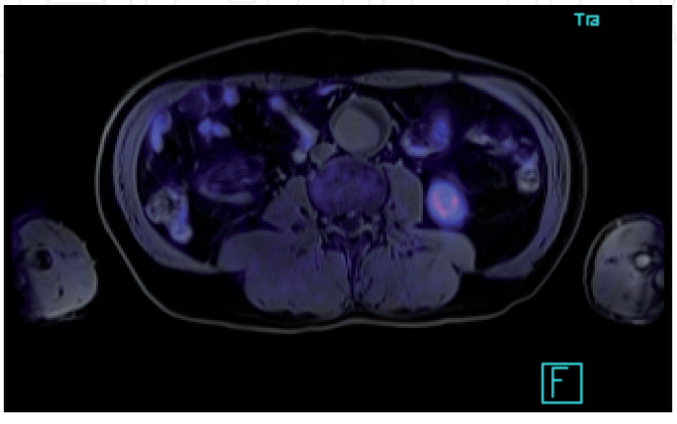

Figure 3. AAA (PET MRI).

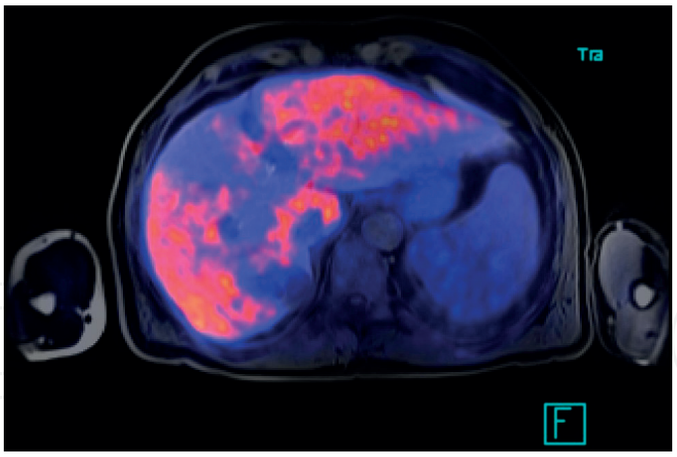

Figure 4. Metastases of colorectal carcinoma in the liver (PET MRI).

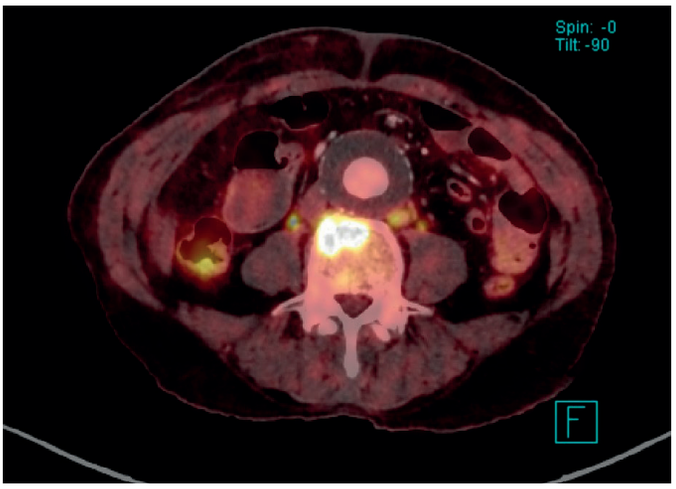

Figure 5. AAA and osteolytic metastasis in the vertebral body (PET CT).

3. Gastrointestinal tract tumors

3.1. Tumors of the stomach

The most common tumor is stomach carcinoma, which is more common in men, with a maximum occurrence in the 6th and 7th decades of life. The only curative treatment is radical tumor resection, and total gastrectomy is indicated if the tumor is in the stomach body. Other supportive forms of treatment, such as chemotherapy or actinotherapy, have been reported to fail, because it is a very aggressive tumor in biological terms. If generalization is present, no resection therapy is indicated in most cases, and therefore no procedures are indicated on the aortic aneurysm, either. The patient's life expectancy in these cases is several months. If a resectable nongeneralized gastric carcinoma occurs concomitantly with AAA (about 2–3.8%) [30], early aggressive radical therapy is advisable (**Figure 6**). In the event of a symptomatic AAA or AAA at risk of rupture, it is best to indicate EVAR treatment, which can soon be

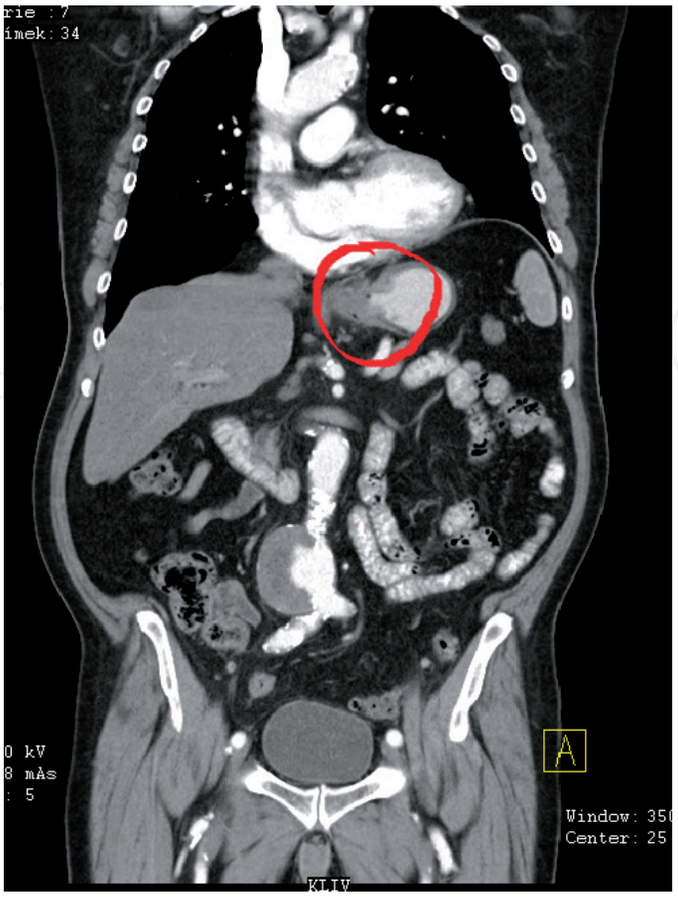

Figure 6. AAA and stomach tumor (CTA).

followed by resection of the tumor. However, EVAR in the first stage of treatment followed by early cancer surgery can also be indicated for asymptomatic AAA. We should not delay the procedure on the stomach due to the biological nature of the disease, and the time interval between the individual procedures may be several days. Stomach surgery is absolutely indicated in the first stage in the case of tumor hemorrhage or perforation. Similarly, we believe it is advisable to indicate the stomach procedure first followed by early EVAR in AAA, which is stable and shows no risk of rupture according to the surgeon. A synchronous procedure is also theoretically possible, especially when both findings are symptomatic or require acute management. If the endovascular procedure is not contraindicated, we always prefer this solution as part of the synchronous procedure. AAA resection and gastrectomy as single-stage surgery is a very extensive procedure and would often be over-limit for the patient. The risk of graft infection is minimal in the synchronous procedure [31–33]. If EVAR cannot be performed for some reason, and we have to choose two-stage surgery, it is possible to use retroperitoneal access for AAA resection (either in the first or second stage). In this way, we can avoid penetration into the peritoneal cavity and prevent later preparation in scar tissues during the second procedure. Similarly, a laparoscopic resection of the stomach can be chosen within the mini-invasive approach [34–35].

Recommendation: in the most common situation, where both pathologies are asymptomatic in terms of risk of AAA rupture or gastric bleeding, we choose malignant tumor surgery in the

first stage and subsequently early endovascular AAA treatment. Even the reverse order of the two-stage procedure is possible, with the stomach procedure being delayed by several days.

3.2. Colorectal tumors

Colorectal carcinomas are among the most common tumors worldwide, and many European countries rank high in regard to their occurrence. They are relatively slow growing tumors, but their metastatic spread often does not correlate with tumor size. Treatment consists of tumor resection and potential subsequent adjuvant chemotherapy. Certain exceptions are locally advanced rectal carcinoma, where preoperative neoadjuvant radiotherapy is indicated. In colorectal tumors concomitant with AAA (about 0.5–3.9%) [30], the symptomatic pathology should be treated first again, e.g., a tumor causing bowel obstruction (**Figure 7**) or bleeding vs. symptomatic painful aneurysm at high risk of rupture. In most cases, however, both lesions are asymptomatic and we have to decide about the treatment strategy. Being aware of the higher risk of AAA rupture after previous laparotomy and of the biological nature of colorectal carcinoma, a two-stage approach should be considered, with EVAR being indicated early after resection of the colorectal carcinoma [11, 36]. For these types of tumors, delaying the intestinal procedure by several days brings minimal risk of malignancy progression. This approach is also beneficial in terms of possible early initiation of adjuvant chemotherapy following tumor resection. Similarly, in rectal tumor, especially if it is locally advanced and infiltrates the surrounding structures, neoadjuvant radiotherapy is primarily indicated before surgery. This may be complicated in the future before subsequent aneurysm surgery, whether using the open-repair or EVAR approach. Therefore, we believe it is again more advisable to indicate EVAR first and to treat the tumor subsequently.

This procedure can also be combined into a single-stage treatment, where EVAR is immediately followed by a surgical procedure on the intestine, where the risk of stent-graft infection

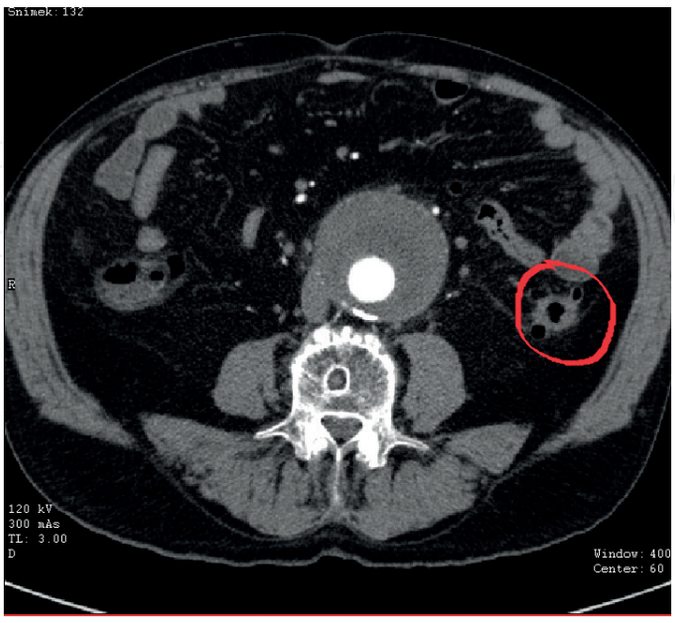

Figure 7. AAA and stenotic colon cancer (CTA).

is reported to be minimal even when handling the large intestine (about 0.5%) [33]. In fact, this number is basically lower than the general risk of aortic replacement infection in open AAA surgery. Recently, the mini-invasive approach, i.e., laparoscopic procedures on the colon and rectum, has been increasingly used in colorectal surgery. This may extend the portfolio of our procedures in some way, especially if AAA cannot be managed by endovascular repair. If we decide to start with the intestinal procedure, it is more than convenient to use the laparoscopic or robotic approach.

With our current capabilities, we are able to use the laparoscopic approach for virtually any procedure in the area of intestinal surgery. Today, laparoscopic procedures are considered to be a standard and noninferior compared to open surgery procedures, and continuous efforts have been made to improve the technique and procedures to further extend the indications and possibilities of this mini-invasive approach. Laparoscopic surgery procedures are now also indicated in patients in whom they were previously contraindicated. The most common cause of these contraindications was previous surgery in the abdominal cavity, obesity, or severe comorbidities, including the presence of AAA. There are no clear literature evidence for higher risk of AAA rupture during laparoscopy. Despite the fact that the laparoscopic approach can be used to perform any procedure in colorectal surgery, the percentage of laparoscopic procedures is still lower than that of open surgery procedures, and is about 20% in the area of colorectal surgery. This percentage applies primarily to clinical facilities. Literary data clearly confirm that laparoscopic procedures reduce hospitalization time, the length of incapacity to work and return to normal life, and in our case, improve the possibility of further surgical procedures on the aorta [37, 38]. The biggest advantage is the mini-invasive approach itself, less trauma of the abdominal wall, less postoperative pain, less analgesics and early rehabilitation and mobilization. Concerning obesity, this is no longer an absolute contraindication to the laparoscopic approach; patients with a body mass index (BMI) of more than 35 are commonly operated on. Obesity markedly impairs the ease of surgery, but the procedure is usually technically feasible. The benefits of laparoscopy for this group of patients is quite high also for another reason: these patients are often at risk of laparotomy dehiscence during open surgery, which then leads to further surgical procedures and potentially increases the risk of a possible AAA rupture. This is also associated with a lower percentage of general complications in the surgical wound area. The issue of radicality, the number of lymph nodes in the resection and survival of patients is comparable to open surgery [39].

From our point of view, a laparoscopic or robotic approach is very beneficial in situations where we are planning an additional surgical procedure on the aorta after intestinal surgery. One of the most important factors is that gentle mini-invasive surgery results in minimal perioperative stress and minimal postoperative changes.

Figure 8 shows a minilaparotomy after laparoscopic resection of the upper rectum for carcinoma, in which EVAR was subsequently indicated for increasing AAA. Such a finding certainly cannot be categorized as a "hostile abdomen" and further potential access to the abdominal cavity is uncomplicated.

Recommendations: for the concomitant occurrence of asymptomatic AAA (which however meets the indication criteria for treatment) and tumor in the colorectal area, we most

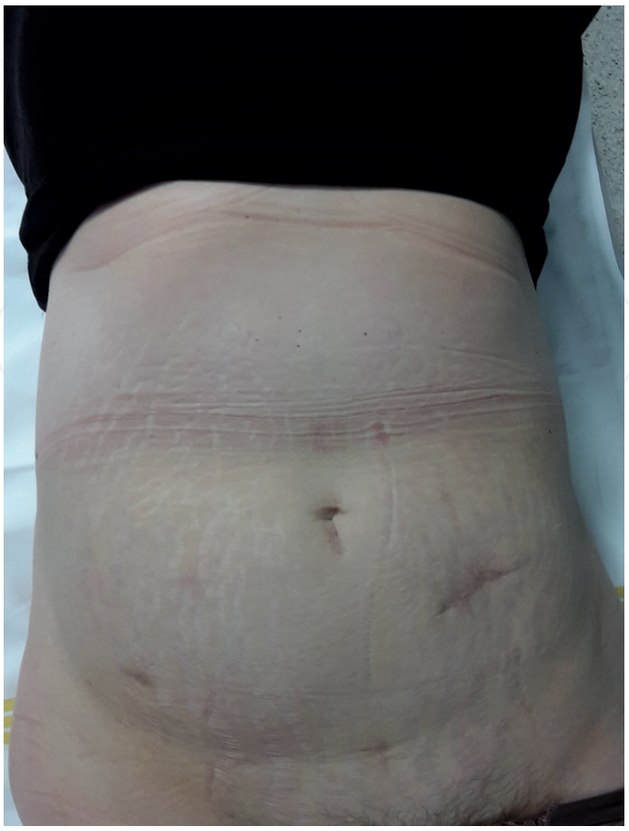

Figure 8. Status postlaparoscopic resection of the rectum.

frequently choose a staged surgery approach, where we prefer EVAR in the first stage and subsequently the intestinal procedure (open or laparoscopic). The reverse order is also possible. In a two-stage surgical approach, we prefer to choose retroperitoneal access to the aorta. A one-stage approach can be chosen in a selected patient group, but this is always associated with a risk of aortic graft infection. We try to avoid this risk by specific measures (AAA resection first, colon resection is started after careful closure of the retroperitoneum, protected vascular graft (antibiotic, silver), antibiotic prophylaxis).

4. Tumors of the liver and biliary tract

The most common primary liver tumors are primary hepatocellular carcinoma (HCC) or cholangiocellular carcinoma (CCC). However, secondary tumors (up to 90%) are predominant in Europe, including metastasis of colorectal carcinoma, carcinoma of the stomach, pancreas, kidneys, mammary glands, etc. Primary liver tumors, as well as gallbladder or biliary tract carcinomas, are biologically very aggressive, with early generalization. Radical resection is the only curative treatment at their early stage without generalization, and other therapeutic methods are only palliative in nature. The incidence of concomitant AAA and primary hepatocellular carcinoma is about 0.3–0.8% [30]. Even here, it is necessary to consider whether any of the pathological findings is immediately associated with a risk of acute complications.

If symptomatic or extensive AAA with a potentially high risk of rupture is not present, it is preferable to first choose surgical treatment of an aggressive malignancy and subsequently continue with an early endovascular procedure on AAA. An example of this procedure is shown in **Figures 8** and **9**, which shows a coincidence of a doubtfully resectable Klatskin tumor and asymptomatic AAA. Here, it is certainly advisable to indicate immediate treatment of the malignancy in the first stage. Of course, the reverse order is also possible, starting with EVAR followed by early tumor surgery. But in this case, we should consider the risk of later stent-graft malposition during the procedure in the abdominal cavity. A slightly different view is available in the case of secondary metastasis in the liver parenchyma (**Figure 10**). If the disease is treatable (e.g., solitary metastasis or a limited number of colorectal carcinoma metastases) and can be managed by liver resection, we first try to perform endovascular AAA repair and continue with an early surgical procedure on the liver. Hepatic metastases of other carcinomas (stomach, gallbladder, and pancreas) unfortunately mostly indicate a very poor prognosis of the disease and no radical procedure is indicated. Even synchronous treatment, including EVAR with hepatic resection, is generally not excluded in liver tumors. If we cannot use EVAR, then the two-stage procedure is the method of choice, and again retroperitoneal (Rutherford) access to the aorta can be used to prevent subsequent postoperative changes in the abdominal cavity.

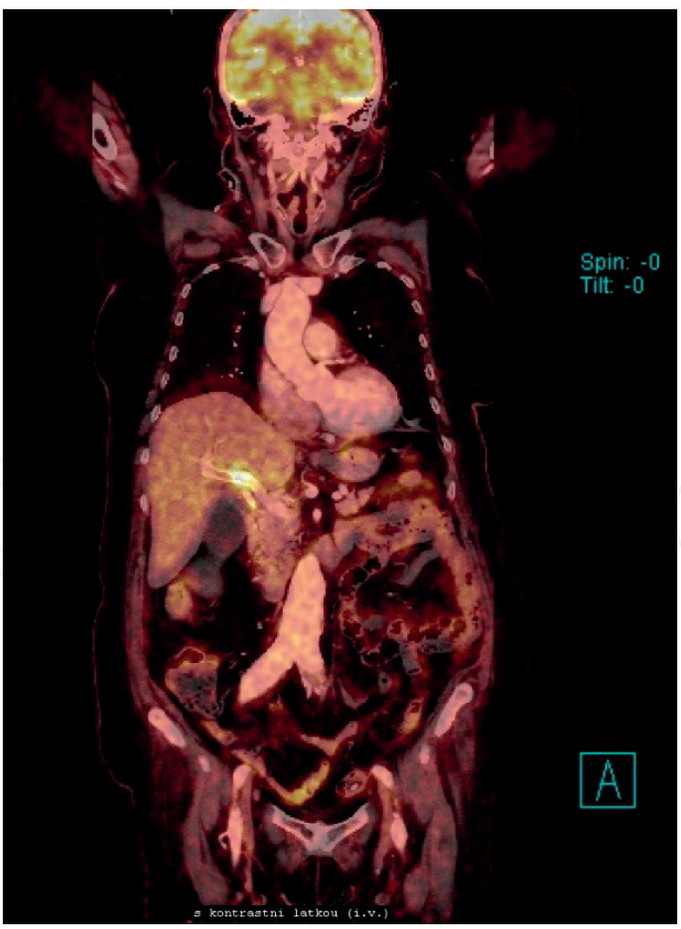

Figure 9. Klatskin tumor and AAA (PET CT).

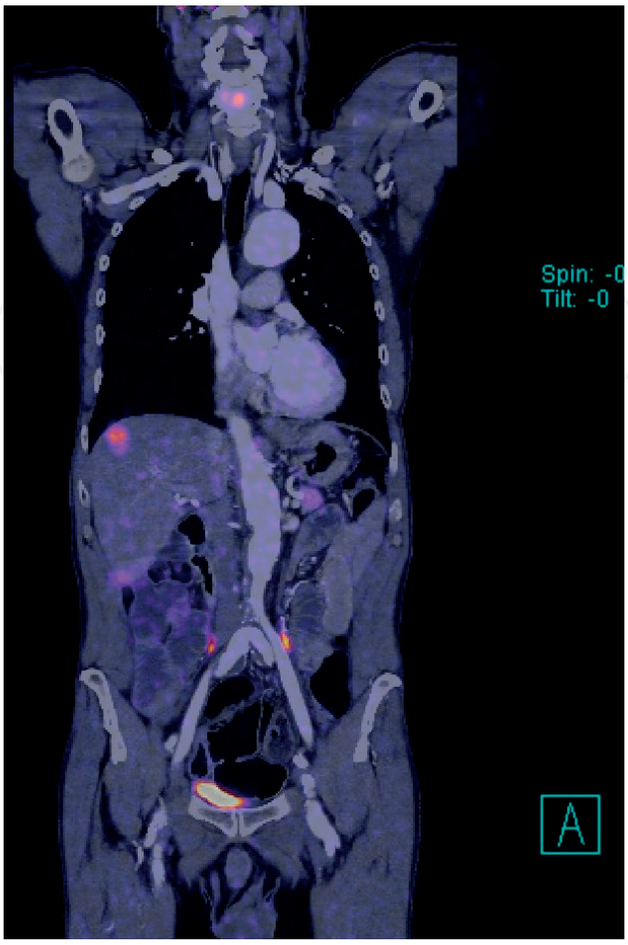

Figure 10. AAA and liver metastasis (PET MRI).

In the vast majority of cases, we try to avoid synchronous open AAA resection and extensive resection of the liver, which would be associated with a disproportionate risk of high blood loss, and a possible risk of infection of the aortic graft. Of course, synchronous treatment can be chosen where small peripheral tumors are present that can be removed by minor resection. More than ever, however, we must take care of precise hemostasis in the resection area (using sutures on the clamp, thermal ablation techniques, harmonic scalpel, and so on). Cell-saver can be helpful in these cases.

Mini-invasive ablation techniques for liver tumor destruction (cryoablation and radiofrequency ablation) can also be added to open AAA resection.

Recommendation: in primary malignant liver tumors (HCC, CCC), we prefer to choose tumor resection in the first stage of treatment, followed by early EVAR. If there is no unnecessary delay, EVAR can be indicated in the first stage of treatment even in this case, and cancer surgery can be added subsequently. In liver metastasis of colorectal carcinoma, we may also allow a moderate delay in the liver procedure (often while undergoing adjuvant chemotherapy), and therefore, it is possible to first indicate EVAR, or less frequently an open aortic procedure. We should avoid simultaneous resection of AAA and larger resection of the liver parenchyma due to the disproportionate risk associated with this procedure.

5. Tumors of the kidney

The most common kidney tumors originate from the renal parenchyma, and less commonly from the pelvis. Renal cell carcinoma affects men twice as often as women. Its maximum occurrence is between 45 and 75 years of age. The only curative method of treatment is radical tumor resection or nephrectomy (depending on tumor size). These tumors are rather aggressive in terms of biological behavior, with early establishment of distant metastatic lesions. The incidence of their concomitant occurrence with AAA is about 1.3–2% [30]. Again, we should consider which pathology is more acute. EVAR can be followed by a renal procedure virtually immediately in several days (laparoscopic management is preferred today), including nephrectomy. Of course, the reverse order of the two-stage procedure is possible as well, with the initial procedure on the kidney followed by early EVAR surgery. The second variant is also supported by the existence of a potential, albeit low, risk of stent-graft malposition during the subsequent nephrectomy. Given the close anatomical location of AAA and the kidney, a simultaneous open procedure is more commonly indicated in these cases. A resection procedure on the kidney, including nephrectomy, is relatively straightforward but does cause additional burden for the patient compared to simple AAA resection. Especially in the case of a left kidney tumor, we choose an optimal retroperitoneal approach, which is an optimal approach to both the renal parenchyma and the aorta. For malignancies on the right side, we must choose a transperitoneal approach. A typical case suitable for simultaneous open access is shown on **Figure 11**, where the endovascular procedure would include a fenestrated or branched stent-graft implantation, and the subsequent renal procedure would be associated

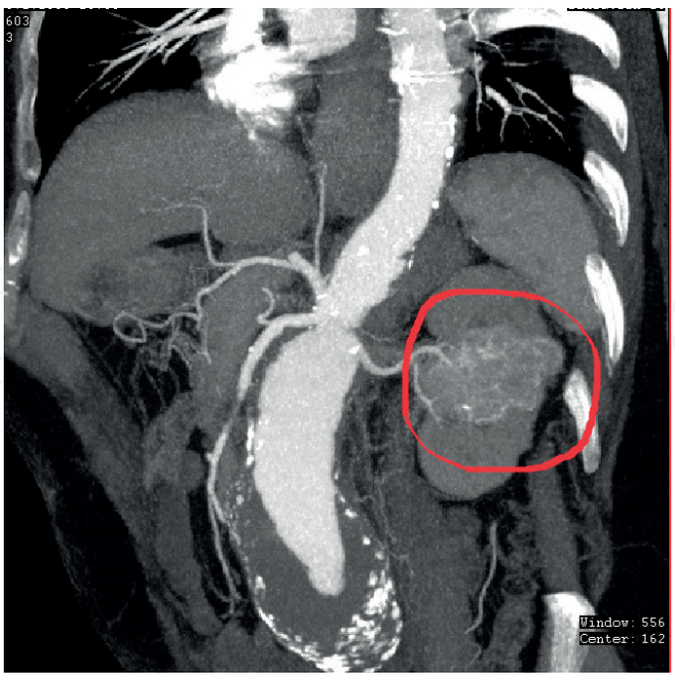

Figure 11. Juxtarenal AAA and renal cell carcinoma (CTA).

with the above risks. A simultaneous open procedure in this case will optimally manage both pathologies in a single-stage procedure. These procedures are not even associated with a higher risk of graft infection. Advanced kidney tumors (T3, T4) with intracaval thrombus are a specific situation, where surgical treatment is also indicated in selected patients, and any aortic manipulation would cause a risk of fatal thrombus embolism in the pulmonary vasculature; in this case, we prefer initial nephrectomy with cavotomy and removal of the tumor thrombus, followed by subsequent AAA management (by an early EVAR procedure, if possible).

Recommendations: again, a two-stage procedure can be chosen to manage the simultaneous occurrence of AAA and kidney tumor, and the EVAR procedure should be preferred again, irrespective of the order. It is more advisable to initiate with tumor management, followed by a subsequent EVAR procedure, whether in terms of early malignancy management or stent-graft malposition. However, a simultaneous open procedure; i.e., AAA resection and kidney tumor resection, including nephrectomy, is indicated more frequently in this area.

6. Other tumors

Cases of concomitant AAA and pancreatic tumors are less common, and similar rules apply as for primary tumors of the liver, gallbladder and biliary tract. Due to the tremendous aggressiveness of the tumor, the pancreatic procedure is always indicated first (unless acute AAA-related symptoms are present), while an EVAR procedure is indicated in the second stage. In patients with an inoperable malignant pancreatic tumor, no aortic procedure is indicated in the vast majority of cases. Coincidence of AAA that cannot be managed by an endovascular procedure for any reason and pancreatic tumor is a difficult situation. Here, we must proceed strictly on an individual basis and consider the optimal approach. However, an open AAA resection with hemipancreatoduodenectomy is not possible, because this simultaneous procedure would be associated with a disproportionate risk of perioperative and postoperative complications. We therefore prefer a two-stage procedure, where it is undoubtedly more appropriate to use the retroperitoneal access to the aorta (whether it is the first or the second stage).

In retroperitoneal tumors, no procedure can generally be recommended, and multiple factors should be considered, such as size and type, location, and in particular biological behavior of the tumor. For malignant tumors, we should prefer extirpation as early as possible, while in uncomplicated procedures, we can use simultaneous AAA resection. However, a two-stage procedure is also available for the latter, with EVAR being preferable to open surgery.

Prostate tumors are often managed by minimally invasive surgery (laparoscopic or robotic prostatectomy, transurethral procedures). So, prostate surgery in the first stage will have minimal effects on the AAA or on the access to potential AAA resection. More often, however, we choose an endovascular procedure, which can be performed simultaneously in indicated cases. A similar approach is chosen for bladder tumors.

7. Our experience

Our university facility includes both a center of vascular surgery with a high number of patients treated for AAA, and a cancer center addressing a complete spectrum of all cancer diseases. For these reasons, we repeatedly encounter patients who have been diagnosed with concomitant AAA and a solid tumor in any location. Of course, the presence of a tumor in the abdominal cavity is a specific situation. If a tumor occurs concomitantly with AAA in any location other than the abdominal cavity, the decision about the treatment strategy is much easier. In the absence of an acute indication for AAA management, surgical treatment for the malignancy is preferable at our facility in the vast majority of cases, which is followed by early AAA management (surgical or endovascular). A different situation occurs when AAA is present concomitantly with an intra-abdominal cancer. We are aware that any treatment for one pathology directly affects the other, and therefore this situation always poses a dilemma for us, as described above, and is carefully considered in a multidisciplinary team. We always try to manage each case on an individual basis, but we still follow certain literary guidelines and use our personal experience.

Over the period from 2000 to 2016, we operated on 1097 patients with AAA, of which 37 patients had a concomitant malignant tumor in the abdominal cavity (3.4%). See **Table 1**.

For each patient, we always used an individual approach, considering the AAA size, symptoms and the risk of rupture, as well as the tumor type, its location, biological nature, and risk of progression of malignancy. The general condition of the patient was also considered. We tried to find the optimal solution in the given situation, but we also respected the patient's own opinion. All discussions take place in a multidisciplinary team (vascular surgeon, radiointerventional radiologist, oncologist, and internist). Our experiences are presented in **Table 2**.

The mean length of hospitalization was 14.9 (±7.1) days for a simultaneous procedure, and 12.3 (±9.3) days for a multistage procedure. The difference was not statistically significant.

The morbidity rate was 24.2% for the simultaneous procedure, and 20.1% for the multistage procedure. Again, the difference was not statistically significant.

No vascular graft infection or stent-graft infection was recorded in any patient, either in the simultaneous or multistage group.

The mortality rate was 11.5% for simultaneous procedures, and 6.9% for multistage procedures. Here, the difference is statistically significant.

Kidney tumor	20
Colorectal tumor	13
Liver tumor	2
Stomach tumor	2

Table 1. Intra-abdominal tumors diagnosed concomitantly with AAA.

Single stage	Open repair (N = 9)
N = 20	EVAR (N = 11)
Multistage	AAA first (N = 10)
N = 17	Tumor first (N = 7)

Table 2. Author's institution experience.

8. Summary

Concomitant AAA and abdominal malignancy is always a very complicated condition requiring early management of both pathologies. This is undoubtedly a dilemma for a surgeon who cannot currently rely on any large randomized trials or mandatory guidelines.

Endovascular repair of AAA (EVAR) resulted in an absolute change in the management of these patients. EVAR can be used in simultaneous or multistage procedures (in any order) with minimal time delay. EVAR is also associated with a minimal risk of stent-graft infections, even in simultaneous procedures. For these reasons, we clearly prefer EVAR in these cancer patients, unless clear contraindications are present. Some authors also address the financial issues of the respective options; the authors of this paper believe that in these specific and relatively rare cases, treatment costs should not play a role in decision-making regarding the treatment strategy.

Acknowledgements

This chapter was supported by Grant of Czech Health Research Council 15-32727A.

Conflict of interest

Author and co-authors have no conflict of interest.

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