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REVIEW ARTICLE

Surgical implantation of malignant cells: A review of evidence from 1850 to present day

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Abstract

Malignant cells, due to decreased cohesion between them, are more likely to exfoliate and implant at distant sites during manipulation. This concern was first expressed by A.G. Gerster in 1885. In this review, we undertook a comprehensive search of the literature to find the evidence for or against the iatrogenic implantation of cancer cells. An exhaustive search on PubMed, Medline, Embase, Science Direct, and Google Scholar yielded 215 relevant publications. The evidence presented in these publications was extracted and synthesized to draw conclusions for this review. Diagnostic and therapeutic procedures through fine/wide bore needles have demonstrated malignant cells in the needle tract but the incidence of recurrences ranges from 0.0003% to 0.9%. There is evidence of malignant cells adhering to surgical instruments, and some reports showed that the number cells needed for successful implantation is 10^6 – 10^7 cells in porcine models. A recent prospective study on colorectal malignancies has shown that the presence of intraperitoneal cells reduced 2-year survival but was not an independent predictor of the outcome. Port site recurrences have been documented since 1978 but the current consensus is more inclined to supporting the improper manipulation of tumor, rather than the laparoscopic procedure itself, as the inducer of port site recurrences. Intraperitoneal morcellation of leiomyomas and leiomyosarcomas does cause intra-peritoneal dissemination of tumor cells. Finally, many approaches to preventing implantation have been explored but lavage of operative site with distilled water may stand as the most promising strategy.

Keywords: Iatrogenic implantation; Malignant cells; Fine needle aspiration; Port site recurrence; Morcellation; Perception and practices

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1. Introduction

The risk of surgical implantation of malignant cells was first mentioned by A.G. Gerster before the New York Surgical Society in February 1885[1] and first published by L.H. Lack in 1896[2]. He documented a series of 35 cases where implantation was the most probable cause of recurrence. Since then, many similar or relevant case reports have emerged, starting with the report by Jackson, Ney, and Fisher in 1959 to at least four reports on implantation metastasis in organs ranging from colon, rectum, anal canal, and thyroid in 2022. Based on other case reports, implantation metastasis in tracheotomy sites,

laparotomy scars, skin graft donor sites, and laparoscopic port sites was also reported. Implantations have also been reported in craniotomy scars of meningiomas. In light of the accumulating evidence, we aimed to review both past and present literature that supports iatrogenic implantation of malignant cells as the one of the triggers of metastasis. In this review, we considered 109 case reports and may have missed a few others which were published in non-indexed journals. In our clinical practice, we have received complaints for invoking metastasis in these cases due to our careless technique, which prompted us to carry out a search of the literature for evidence on this phenomenon.

2. Methods

A comprehensive search on PubMed, Medline, Embase, Science Direct, and Google Scholar was conducted. The MeSH terms used included "cancer cell implantation," "implantation of malignant cells," "iatrogenic implantation tumor cells," "cancer seeding instruments," "residual tumor cells wash water," "residual tumor cells surgical instruments," "residual tumor cells wounds," and "skin/cutaneous recurrence." Publications published from 1885 to 2022 were targeted in this literature search.

All results were examined for relevance by briefly checking the title of publications. The publications were sorted according to type and year of publication. All relevant publications were selected from the list after a quick review of the abstracts by two authors. Finally, evidence was extracted from the text and synthesized by two other authors. The final manuscript was edited by two authors. This review is prepared and written as per the PRISMA statement for reporting systematic reviews and meta-analyses[3].

3. Results

The search yielded 53,087 results of which 175 seemed relevant. When sorted by date of publication, another 14 were found irrelevant, leaving behind 161 relevant studies. Out of the filtered publications, there were 94 case reports/case series, 22 animal experiment studies, and 13 studies on human subjects. Seven human studies were of prospective nature, seven were retrospective (a few studies included animal experiments and retrospective observation in humans), and one was cross-sectional. There were 16 reviews and one survey. No studies reporting randomized or non-randomized trials were found among the selected publications. A further search of cross-references yielded another 67 studies, of which 12 were irrelevant and one was a duplicate study, leaving behind 54 relevant studies. There were four trials, five prospective and three retrospective studies, eight cross-sectional studies, four animal experiments, two human experiments, 10 case reports/case series, 16 reviews, and two meta-analyses. Figure 1 presents a summary of the above-mentioned results, and Figure 2 summarizes the results from search of cross-references.

4. Discussion

4.1. Modes of iatrogenic implantation

A recurrent growth of cancer cells can be suspected of being iatrogenic when a tumor sharing the same histology as the original cancer occurs at a site distant from the field of intervention or outside the lymphatic basin of the primary tumor. The most probable explanation for this phenomenon is the transfer of cells through surgical supplies, lavage water, *etc.* These recurrences have been reported at sites of tracheostomy and percutaneous gastrostomy in head-and-neck cancers, at graft donor sites in sarcomas, on abdominal incision scars, and at laparoscopic and thoracoscopic port sites. They have also been reported in the needle tract of fine/wide bore needle aspiration sites.

Common modes of implantation of malignant cells in present-day scenario include:

(1) Implantation through surgical instruments and supplies.
(2) Implantation during diagnostic/therapeutic procedures using fine/wide bore needles.
(3) Intraperitoneal and port site implantation.
(4) Implantation due to intraperitoneal morcellation of tumor.

The ensuing review will discuss the history of implantation and the evidence for or against the above modes of implantation, and examine the efficacy of preventive measures.

4.2. History

Charles Ryall[4] first pointed out the danger of implantation of cancers cells and advocated changing of drapes, instruments, *etc.* Cole *et al.*[5] studied suture line recurrence in colorectal cancers after resection and noted that smears taken from the lumen outside the ligature used to isolate the resected segment of colon showed no cells as opposed to smears from inside the ligature. A retrospective study of gastric cancer patients undergoing curative surgery from 1931 to 1957 showed wound recurrence in 1.9% of 569 patients[6]. In addition, Haverback and Smith[7] proved that cancer cells can be transplanted by suture in mouse experiments while tumor cells have been demonstrated to adhere to surgical knives[8]. During this period, many animal experiments have been conducted to demonstrate the implantation of cancer cells as well as several methods of prevention have been introduced. A comprehensive review of the evidence was published by Colin Thomas Jr[9] in 1961. It was found that two to three million Ehrlich's

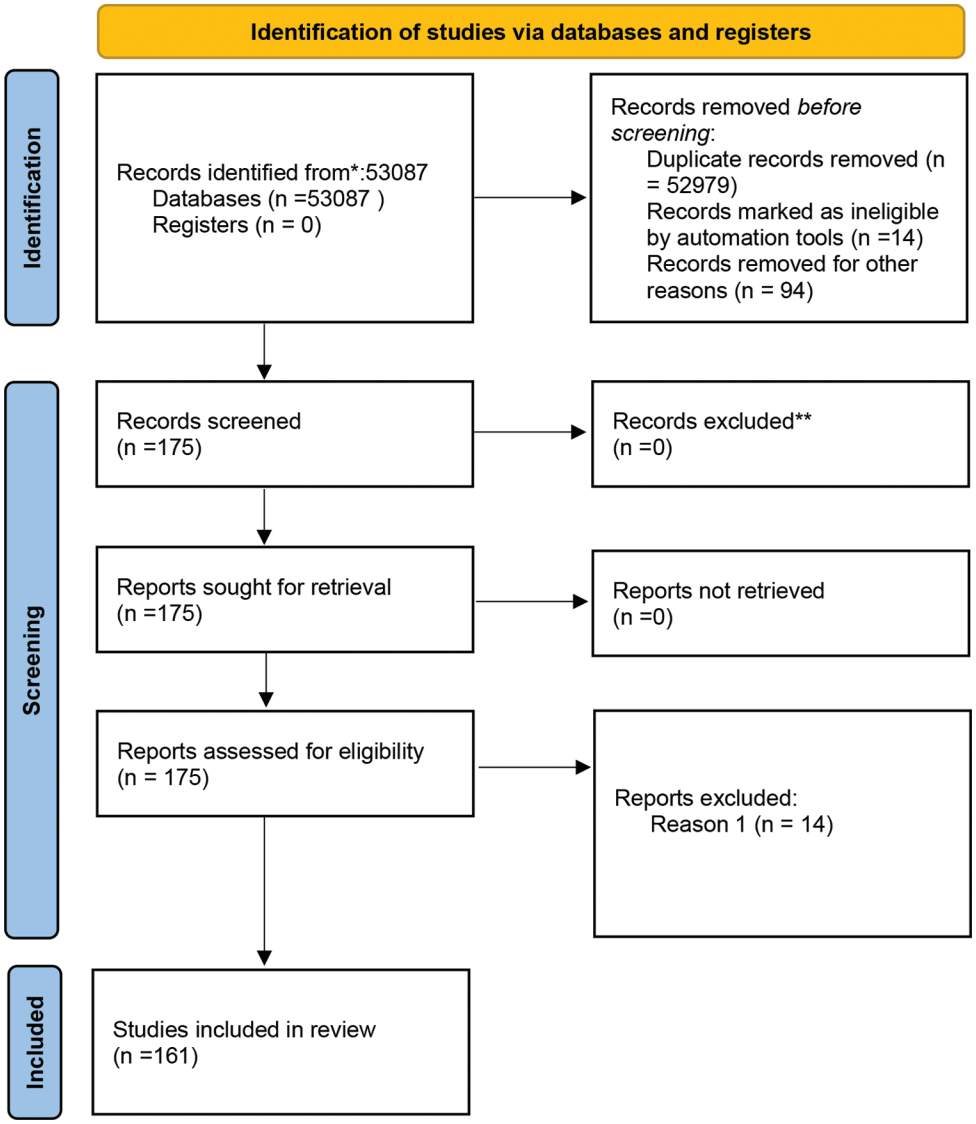


Figure 1. PRISMA flowchart showing identification of studies from database.

ascites tumor cells were needed to cause pulmonary metastasis and 300,000 to 500,000 cells were needed in the case of peritoneal metastasis. Similar findings were published by Southam and Brunshwig[10], who also found that subcutaneous nodules did not resulted following auto-transplantation with an inoculum of less than one million cells in humans.

4.3. Implantation during cytology

Clark *et al.* first reported implantation of malignant cells of the prostate at the site of fine needle aspiration in 1953[11]. This was followed by reports of implantation using Trucut, Vim-Silverman, Moonen, Turkel, 14-gauge needle, and other unspecified needles[12]. In a quantitative study on seeding of melanoma cells in patients with intraocular melanomas using the 30-gauge needle tracts, Glasgow *et al.* compared the number of cells found in needle tracts to the number needed to cause growth of tumors in animal models and found much fewer cells in the needle tracts[12]. In 1998, Mighell and High[13] examined serial sections of resected cancer specimen of six patients known to have undergone fine-needle aspiration of head-and-neck tumors. Needle tract was identified in two of six specimens, and both cases demonstrated tumor cells along the tract. Smith[14] investigated the incidence of needle tract seeding through questionnaires sent to 470 hospitals. He found an incidence of one in 16,381 biopsies, which compared favorably to the results of previous surveys of two in 11,700 biopsies and two in 66,937 biopsies. Risk of implantation during therapeutic and diagnostic procedures on primary

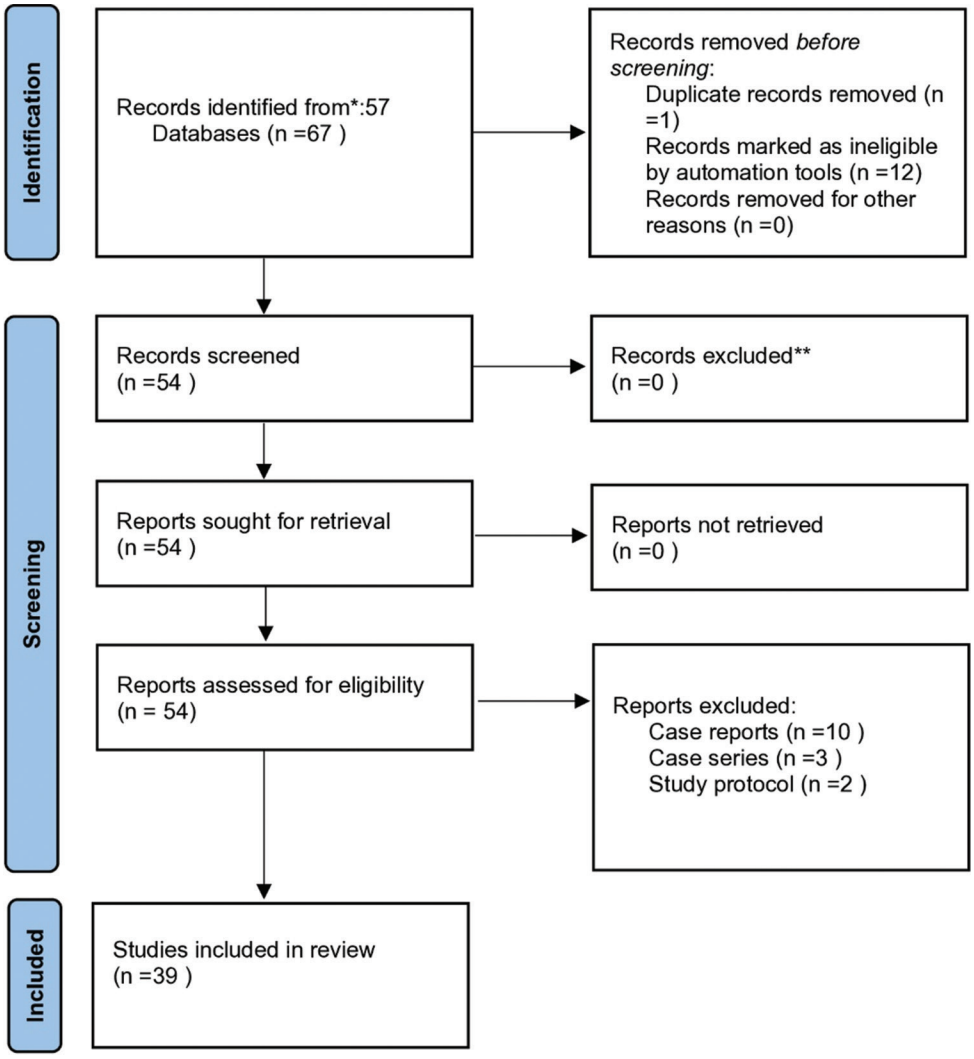


Figure 2. PRISMA flowchart showing identification of studies from cross-references.

liver cancers has been found to be about 0.9% in a large multi-center study[15]. Evidence for the same in metastatic tumors is lacking.

More evidence revolving around tumor cell seeding during needle biopsy in breast cancer is available in the literature. Loughran and Keeling[16] reviewed the evidence and found that tumor cell displacement occurred in 76 out of 352 patients undergoing large core needle biopsy. The incidence of seeding was 42% if the interval between biopsy and examination of tract was <15 days but only 15% if it was 28 days or more. The local recurrence rate in 71% of 313 patients who have been subjected to pre-operative percutaneous biopsies was 11%, but the rate dropped to 3% when radiotherapy was applied but maintained at 34% if the patients were not given radiotherapy.

4.4. Head-and-neck cancers

Smith *et al.*[17] analyzed the smears from the washing of the incision site after radical surgery for cancer in 111 patients, of which 53 had head-and-neck cancers. They investigated if any part of local failure could be explained by cancer seeding on the wound. There was a slight difference in local recurrences between positive and negative smears which did not reach statistical significance ($P \leq 0.07$). Similar studies by Harris and Smith[18] in 69 patients of head-and-neck cancers, analyzed using life-table methods, failed to detect significant differences in local recurrence rates or time to recurrence. Sako *et al.*[19] performed cytological examination of wound washings and wound drainage fluids, collected in 24-h aliquots, for 72 h postoperatively in 60 patients with head-and-neck cancers. At the end of surgery, 15% of patients with negative wound irrigation showed malignant cells in their wound drainage and two

patients developed skin recurrences in the neck during follow-up. The presence of cancer cells in washings from the surgeon's gloves and instruments has been documented by Curran *et al.*[20]. These findings and observations are clear indications that exfoliated cancer cells are present in wound washings, drainage fluid, and washings from surgical gloves and instruments and can implant in the cut surfaces and wounds, thereby causing local and cutaneous failures. However, none of the previous studies have been able to detect a statistically significant association between positive smears and local and distant failures.

Many animal experiments have been conducted to explore methods to prevent the implantation of cancer cells. In each experiment, an aggressively growing tumor strain was used, and about 10,000 – 5,000,000 cells were required for successful implantation in small animals[21-24] while 10^6 – 10^7 cells in porcine models[25]. These figures have been corroborated by different researchers[9,10]. Studies designed to enumerate the viable cells in these washings are hitherto unavailable. To quote Dr. George E. Moore[22], "… if you have a patient with far-advanced carcinoma of the stomach and inoculate him with cells from his own cancer, subcutaneously, they will grow only 10 – 15% of the time."

4.5. Abdominal and peritoneal implantation

In 1952, on the findings of 10.9% recurrence in suture lines in 55 patients of colorectal cancer, Cole[26] reasoned that (i) based on previous evidence, colorectal cancer is susceptible to proximal, rather than distal, lymphatic spread; (ii) surgeons remove about 5 centimeters of bowel proximally and distally so they do not go through the tumor; and (iii) recurrences were found only on end-to-end anastomosis and not if a proximal segment end colostomy has been performed; given these reasonings, the recurrence must have been caused by the implantation of malignant cells originating in the colonic lumen. Fortner *et al.* recorded recurrent tumors in the abdominal wall in 1.9% of gastric carcinomas[6]. The viability of these tumor cells and their ability to leak through an anastomosis and cause local recurrence has been documented in 1984[27] and 1989[24]. A study on exfoliated cells implanted on rats has shown that the cell growth occurred on damaged mucosa but the intact mucosa was completely resistant to implantation[28]. The presence of free peritoneal tumor cells[29] has a positive predictive value of 91% and specificity of 97% for tumor recurrence. A systematic review on free intraperitoneal tumor cells concluded that their presence was a negative prognostic factor in colorectal cancers[30]. Howver, results of the recent EVOCAPE 2[31] multicenter prospective study showed that although 2-year survival was significantly lower in patients with intraperitoneal cancer cells, it was not an independent predictor on multivariate analysis. Probably, the frequency at which these shed tumor cells result in perioperative metastasis is difficult to measure[32].

4.6. Port site metastasis

The first case of port site metastasis was reported in a patient of malignant ovarian ascites[33] and since then whether the laparoscopic procedure or the physical effect of the procedure triggered the metastasis has been a subject of debate. It has been reported following laparoscopic resection of gallbladder, ovarian, gastric, lung, colonic, and other malignancies but the greatest number have occurred after colonic resection (<35)[25]. Port site metastasis in colorectal cancers have been studied in much greater detail than cancers of other sites. It has been found that over a 2-year period the incidence of port site metastasis varies from 0 – 2.3% [25,34]. Two reviews[34,35] list tumor cell spillage, tumor aggressiveness (stage and grade), and pneumoperitoneum as the possible risk factors. Quantitative measurements of residual cancer cells after robotic-assisted radical cystectomy revealed that cancer cells can be found in most pelvic washes and a majority of these patients developed recurrence within 2 – 16 months[36]. A meta-analysis of 1182 subjects demonstrated that the presence of both pre-resection and post-resection tumor cells increased the odds ratio of local and overall recurrence[37]. An investigation into the effect of carbon dioxide pneumoperitoneum in T cell immune-deficient nude mice model revealed no difference in intraperitoneal implantation[38] as compared to gasless laparoscopy. In another experiment comparing pneumoperitoneum, gasless laparoscopy, and laparotomy, the authors found significant differences in total tumor load and growths at omentum and scrotal fat in mice subjected to carbon dioxide pneumoperitoneum[39]. These contradictory results point to the fact that there is no consensus on the etiology of port site recurrence.

Many other theories have been advanced to explain port site metastasis, including "chimney effect" due to leakage of gas along trocars[40], aerosolization of tumor cells, and direct contamination of trocar site by surgical instruments[41]. Often, port site recurrence is detected at the site of specimen retrieval due to tumor spillage[42]. Morcellation of the specimen can also cause intraperitoneal dissemination of cancer[43]. In their review on the etiology of port site recurrences, Whelan and Lee opined that poor surgical technique leading to traumatization of the tumor is the principal cause of the release of substantial number of cells, which is a prerequisite to port site recurrence. As the surgeon gains experience in laparoscopic surgery, his tumor handling improves, decreasing the number of exfoliated malignant cells and the incidence of port site recurrences. The rate of port site recurrences now drops

to match the incidence of abdominal scar recurrences in open colectomy[25].

4.7. Cutaneous metastasis

Cutaneous metastasis of internal malignancy is a rare event with incidence rates ranging from 1.0% to 4.6%[44]. Metastasis usually develops at the umbilicus, in surgical scars, at laparoscopic port sites, and near metastatic lymph nodes. However, the most common source of dermal metastasis in the face and neck is oral cavity cancer[45]. A retrospective study on patients who had been subjected to excision of primary tumor and neck dissection and then developed skin metastasis revealed that previous skin involvement, extracapsular extension of metastatic nodes, and indication for chemotherapy are predictors of dermal metastasis, irrespective of stage[46]. These cutaneous metastasis are painless, solitary, or multiple nodules separate from the overlying epidermis and distinct from direct skin invasion[47]. Other cutaneous metastasis can be divided into metastatic umbilical tumors or Sister Mary Joseph nodules (SJNs) and non-SJN metastasis. The non-SJN metastases are further subdivided into those occurring due to surgery, injury, or lymphadenopathy. In non-SJNs, direct implantation, hematogenous spread, and extranodal extension play a key role. Thereafter, the tumor cells hinge on the factors involved in wound healing and inflammation for proliferation[44]. An unusual case of metastasis of adenocarcinoma of the colon to the skin of the right groin, scrotum, and perineum presenting as erythema, papules, and fake blisters has been reported[48], stating that Koebner phenomena maybe involved.

4.8. Iatrogenic myoma

When uterine leiomyomas ("fibroids") are treated with laparoscopic myomectomy or sub-total hysterectomy, the tumor must be cut into pieces or morcellated to enable extraction. If a power morcellator, which cuts the tumor into cores of 1 cm diameter, is used, there will be intraperitoneal dispersal of microscopic tumor fragments. The first few cases regarding this have been reported in 2003[49] and 2005[50], documenting intraperitoneal dissemination of endometrial tissue visualized by means of post-operative histopathology. Seidman *et al.*[51] investigated 1091 instances of morcellation and found leiomyoma variants or atypical and malignant smooth muscle tumors in 1.2% cases, including endometrial stromal sarcoma, cellular leiomyoma, atypical leiomyoma, smooth muscle tumor of uncertain potential (STUMP), and leiomyosarcoma. Moreover, they documented disseminated disease in 64.3% of all tumors. Nezhat and Kho[52] reviewed reports of parasitic myomas (pedunculated myomas that have lost their attachment to the uterus and become parasitic on surrounding organs), in which eight of 15 reports had been published between 2004 and 2009. Eleven out of 16 patients had a past history of surgery, which involved electric morcellator in six cases and some unspecified form of morcellation in the other five cases. The majority of the parasitic myomas were found in the pelvis but three were located in the upper right quadrant near the liver and gallbladder. Nezhat and Kho also recorded at least five reports of leiomyomatosis peritonealis disseminata (LPD) occurring in association with laparoscopic myomectomy and the use of morcellators. LPD is a rare benign condition characterized by multiple smooth muscle myofibroblastic and fibroblastic nodules on the peritoneal surfaces of pelvic and abdominal cavities on the surface of the uterus, intestines and abdominal walls. Based on the findings of these reports, the parasitic myomas are christened "iatrogenic myomas." The Clinical Practice Guidelines[53] reviewed by Gynecology Guideline Management and Oversight Committees and the Executive of the Society of Gynaecologic Oncology of Canada (GOC) recommend that:

(1) Morcellation is contraindicated in established cancer, pre-cancerous lesions, or suspected cancer.
(2) Patients should be counseled about the risks (malignant and non-malignant), benefits, and alternatives as part of informed consent.
(3) Morcellation should be avoided in hereditary cancer syndromes that predispose to uterine malignancies.

4.9. Present-day beliefs and practices

Early in 1937, an editorial published in *The New England Journal of Medicine* made a mention regarding the search for tumor cells on surgical knives used for the surgery of malignant tumors[8]. This had then been reiterated by Curran *et al.* in 1996[20]. A prospective study of the gloves and instruments used in head-and-neck cancer surgeries found cells in all washings.

Yu *et al.* attempted to study each surgical supply separately in patients undergoing D2 resection for gastric cancers[54]. Surgical supplies were divided into five groups: (i) Surgical instruments; (ii) surgical gloves of the surgeon, first assistant, and second assistant; (iii) surgical gloves and gauze used by the scrub nurse; (iv) gauze used to clear operative field; and (v) stapler devices. The immersion fluid was centrifuged and the precipitate was cultured in 20% bovine fetal serum with 5% carbon dioxide. Although exfoliated cells were found in all five groups of supplies, they were most frequent in the gloves and gauze used by the scrub nurse and the gauze used to clear the operative field. Many authors have recommended that surgical instruments and drapes be changed when moving from one anatomical field to another, *for example*, from site of resection to site of harvest of flap. They also suggested that

the site of resection be thoroughly washed before moving on to reconstruction.

Berger-Richardson *et al.* investigated the beliefs and practices of surgeon regarding glove and instrument changes[55]. They conducted a mailed survey among surgeons registered with the College of Physicians and Surgeons of Ontario to investigate how surgeons handle gloves and instruments used in cancer resection, the strategies used to prevent cancer seeding, and whether they believe gloves and instruments can be vectors for cancer cell seeding. They found that 52% of the respondents had changed gloves and 40% had changed instruments. The most commonly cited reasons for such action were "gut feeling," clinical training, and clinical observation. Only 4% cited evidence as the reason for changing. Surgeons with fellowship training in general surgical oncology or breast were more likely to change gloves and instruments than surgeons trained in site-specific oncology or without training in oncology.

Caudill *et al.* investigated the increased cost stemming from practicing these precautionary measures, which is ultimately passed on to the patients[56]. The authors stated that all these precautionary measures may not be essential because most of the breast reconstruction surgeries target low-stage tumor and there is no convincing evidence that breast cancer cells can successfully circulate, seed or implant in other anatomical areas. Based on a conservative estimate, the patient is expected to bear a "precaution fee" amounting to $1231.83 per surgery.

4.10. Prevention of implantation

Can the implantation of cancer cells be prevented? Is mechanical washing using saline sufficient or is a cytotoxic/cytostatic agent needed? Among the multitude of chemicals tested on animal models were sodium hypochlorite, nitrogen mustard, ethyl alcohol, 5% formaldehyde, thiotepa, *etc.*[5,21-23]. Most authors found nitrogen mustard and formaldehyde to be effective. Nash *et al.*[57] found proflavine hemisulfate to be effective while topical oxaliplatin was also found to prevent port site metastasis[58]. More modern approaches entail the introduction of drug-loaded hydrogels[59] and dehydrated ethanol[60] into the surgical cavity, which have been proven to successfully prevent implantation of cancer cells. Electron therapy, if done within 10 – 15 days of thoracoscopy, has been found to be effective in impeding the implantation of cancer cells in patients with malignant mesothelioma after invasive thoracoscopy[61].

Ito *et al.*[62] investigated the tumoricidal effects of hypo-osmolar distilled water *in vitro* and in mice *in vivo*. The *in vitro* assay showed tumor cell lysis in 15 min and a significant decrease in intraperitoneal tumor volume in mice treated with distilled water. Therefore, the authors concluded that a water lavage, although not curative, may delay peritoneal outgrowth and prolong survival of patient.

The possible role of intraoperative rectal washout has been investigated by Terzi *et al.*[63]. Local recurrence rates were similar in rectal washout and no washout groups, and none of the patients developing local recurrence had malignant cells on the circular stapler. After reviewing the evidence regarding utility of rectal washout and types of washout, Okoshi *et al.*[64] opined that there is insufficient evidence to recommend one washout solution over another or even that a rectal washout is potent enough to decrease the risk for anastomotic recurrence. Nevertheless, a rectal wash does not appear to damage the rectum and may be used before anterior resection.

Schneider *et al.*[65] studied the prevention of port site recurrences in a porcine model and concluded that surgical technique has a major influence on recurrence. These results are in concordance with results of human studies where contamination of instruments and trocars with cancer cells was much higher than contamination of carbon dioxide. Therefore, the measures recommended by Tsivian and Sidi[66] for the prevention of port site recurrence in urologic surgery may be applied to all laparoscopic surgery and are listed below:

(1) Sufficient technical preparation
(2) Avoidance of laparoscopic surgery if ascites is present
(3) Trocar fixation with avoidance of gas leakage along the trocar
(4) Avoidance of tumor boundary violation
(5) Cautious consideration of morcellation
(6) Use of an impermeable bag if morcellation is done
(7) Use of a bag for intact specimen removal
(8) Drainage placement, if needed, before abdomen deflation
(9) Povidone-iodine irrigation of the laparoscopic instruments, trocar, and port site wounds
(10) Suturing of 10-mm trocar wounds

A retrospective study[67] on 446 patients undergoing cytoreduction for ovarian cancer, among which port site excision had been performed to prevent port site recurrence in 82 patients, found no difference in survival between those with port site excision and those without. A higher incidence of wound complications was seen in the excision group. The authors suggested that no port site resection be done in patients without microscopic evidence of port site recurrence.

5. Conclusions

Despite the evidence of cancer cells implantation from the contaminated surgical sutures and knives, successful

implantation may require up to 2 – 3 million cells. The most robust evidence of implantation of tumor cells along needle tracts is in the core biopsy needles from breast cancers, but with a measly incidence rate of implantation measuring at 0.9%. However, fine needle aspirations are considered oncologically safe procedures with very low rates of implantation and tract recurrences. Multiple studies have demonstrated the presence of malignant cells in wound washings and wound drainage fluid but these studies failed to detect a significant increase in local or cutaneous recurrences due to their presence. Although viable intraperitoneal tumor cells have been detected and found to cause intraperitoneal recurrences, the EVOCAPE 2 prospective study failed to establish it as an independent predictor of local recurrence. Laparoscopic surgery of intraperitoneal tumors is generally regarded as one of the factors contributing to port site recurrences, but poor surgical technique leading to excessive tumor handling remains the most probable cause. In addition, peritoneal implantation of benign myomas and accidental leiomyosarcoma has become a clinically known fact; therefore, appropriate precautions must be taken if intraperitoneal morcellation is involved as part of the treatment. At present, lavage of the surgery site with distilled water is the most effective method to prevent the implantation of malignant cells.

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Conflict of interest

The authors declare that they have no conflict of interest to declare.

Author contributions

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Ethics approval and consent to participate

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Consent for publication

Not applicable.

Availability of data

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References

1. Gerster AG, 1885, On the Surgical Dissemination of Cancer. New York: New York Surgical Society. p98–109.
2. Lack LH, 1896, A contribution to the operative treatment of malignant disease of the larynx,with special reference to the danger of cancerous wound infection. *Lancet*, 147: 1638–1641.
3. Moher D, Liberati A, Tetzlaff J, *et al*., 2010, Prefered reporting items for systematic reviews and meta-analyses: The PRISMA statement. *Int J Surg*, 8: 336–341.
   https://doi.org/10.1016/j.ijsu.2010.02.007
4. Ryall C, 1907, Cancer infection and cancer recurrence: A danger to avoid in cancer operations. *Lancet*, 170: 1311–1316.
5. Cole WH, Roberts S, Watne A, *et al*., 1958, The dissemination of cancer cells. *Bull New York Acad Med*, 34(3): 163–183.
6. Fortner JG, Lawrence W, 1960, Implantation of gastric cancer in abdominal wounds. *Ann Surg*, 152(5): 789–794.
   https://doi.org/10.1097/00000658-196011000-00003
7. Haverback CZ, Smith RR, 1959, Transplantation of tumour by suture thread and its prevention: An experimental study. *Cancer*, 12(5): 1029–1042.
   https://doi.org/10.1002/1097-0142(195909/10)12:5<1029::aid-cncr2820120524>3.0.co;2-q
8. The transfer of tumor cells by the surgical knife, 1937, *N Engl J Med*, 216(13): 570.
9. Thomas CGJ, 1961, Tumor cell contamination of the surgical wound: Experimental and clinical observations. *Ann Surg*, 153(5): 697–704.
   https://doi.org/10.1097/00000658-196105000-00008
10. Southam CM, Brunshwig A, 1961, Quantitative studies of autotransplantation of human cancer. *Cancer*, 14: 971–978.
11. Clarke BG, Leadbetter WF, Campbell JS, 1953, Implantation of cancer of the prostate in site of perineal needle biopsy: Report of a case. *J Urol*, 70(6): 937–939.
    https://doi.org/10.1016/S0022-5347(17)68008-X
12. Glasgow BJ, Brown HH, Zargoza AM, *et al*., 1988, Quantitation of tumor seeding from fine needle aspiration of ocular melanomas. *Am J Ophthalmol*, 105(5): 538–546.
    https://doi.org/10.1016/0002-9394(88)90248-6
13. Mighell AJ, High AS, 1998, Histological identification of carcinoma in 21 gauge needle tracks after fine needle aspiration biopsy ofhead and neck carcinoma. *J Clin Pathol*, 51: 241–243.
    https://doi.org/10.1136/jcp.51.3.241
14. Smith EH, 1991, Complications of percutaneous abdominal fine-needle biopsy. *Radiology*, 178(1): 253–258.

https://doi.org/10.1148/radiology.178.1.1984314

15. Livraghi T, Lazzaroni S, Meloni F, *et al*., 2005, Risk of tumour seeding after percutaneous radiofrequency ablation for hepatocellular carcinoma. *Br J Surg*, 92: 856–858.

https://doi.org/10.1002/bjs.4986

16. Loughran CF, Keeling CR, 2011, Seeding of tumour cells following breast biopsy: A literature review. *Br J Radiol*, 84: 869–874.

https://doi.org/10.1259/bjr/77245199

17. Smith RR, Thomas LB, Hilberg AW, 1958, Cancer cell contamination of operative wounds. *Cancer*, 11(1): 53–62.

https://doi.org/10.1002/1097-0142(195801/02)11:1<53::aid-cncr2820110113>3.0.co;2-x

18. Harris AH, Smith RR, 1960, Operative wound seeding with tumor cells: Its role in recurrences of head and neck cancer. *Ann Surg*, 151(3): 330–334.

https://doi.org/10.1097/00000658-196003000-00004

19. Sako K, Marchetta FC, Burke EM, *et al*., 1963, A study of wound drainage fluid for tumor cells as a source of recurrence. *Am J Surg*, 106(5): 797–801.

https://doi.org/10.1016/0002-9610(63)90404-5

20. Curran AJ, Smyth D, Kane B, *et al*., 1996, Exfoliated malignant cells in glove and instrument washings following head and neck surgery. *Clin Otolaryngol Allied Sci*, 21(3): 281–283.

https://doi.org/10.1111/j.1365-2273.1996.tb01742.x

21. McDonald GO, Gines SM, Cole W, 1960, Wound irrigation in cancer surgery. *AMA Arch Surg*, 80: 920–927.

22. Hatiboglu I, Moore GE, Wilkins HJ, *et al*., 1960, Effects of chemotherapeutic agents on wounds contaminated with tumor cells: An experimental study. *Ann Surg*, 152(4): 559–567.

https://doi.org/10.1097/00000658-196010000-00001

23. Thomas CG Jr., Brown BC, 1960, Studies on the prevention of surgical implantation of cancer. *Ann Surg*, 151(4): 581–588.

https://doi.org/10.1097/00000658-196004000-00020

24. O'Dwyer PJ, Martin EW Jr, 1989, Viable intraluminal tumour cells and local/regional tumour growth in experimental colon cancer. *Ann R Coll Surg Engl*, 71: 54–56.

25. Whelan RL, Lee SW, 1999, Review of investigations regarding the etiology of port site tumor recurrence. *J Laparoendosc Adv Surg Tech A*, 9(1): 1–16.

https://doi.org/10.1089/lap.1999.9.1

26. Cole WH, 1952, Recurrence in carcinoma of the colon and proximal rectum following resection for carcinoma. *Arch Surg*, 65(2): 264.

https://doi.org/10.1001/archsurg.1952.01260020277008

27. Umpleby HC, Fermor B, Symes MO, *et al*., 1984, Viability of exfoliated colorectal carcinoma cells. *Br J Surg*, 71(9): 659–663.

https://doi.org/10.1002/bjs.1800710902

28. Hubens G, Lafullarde T, Van Marck E, *et al*., 1994, Implantation of colon cancer cells on intact and damaged colon mucosa and serosa: An experimental study in the rat. *Acta Chir Belg*, 94(5): 258–262.

29. Nekarda H, Geb C, Stark M, *et al*., 1999, Immunocytochemically detected free peritoneal tumour cells (FPTC) are a strong prognostic factor in gastric carcinoma. *Br J Cancer*, 79(3–4): 611–619.

https://doi.org/10.1038/sj.bjc.6690096

30. Mohan HM, O'Connor DB, O'Riordan JM, *et al*., 2013, Prognostic significance of detection of microscopic peritoneal disease in colorectal cancer: A systematic review. *Surg Oncol*, 22(2): e1–e6.

https://doi.org/10.1016/j.suronc.2013.01.001

31. Cotte E, Peyrat P, Piaton E, *et al*., 2013, Lack of prognostic significance of conventional peritoneal cytology in colorectal and gastric cancers: Results of EVOCAPE 2 multicentre prospective study. *Eur J Surg Oncol*, 39(7): 707–714.

https://doi.org/10.1016/j.ejso.2013.03.021

32. Craig DH, Downey C, Basson MD, 2008, SiRNA-mediated reduction of α-actinin-1 inhibits pressure-induced murine tumor cell wound implantation and enhances tumor-free survival. *Neoplasia*, 10(3): 217–222.

https://doi.org/10.1593/neo.07945

33. Döbrönte Z, Wittmann T, Karácsony G, 1978, Rapid development of malignant metastases in the abdominal wall after laparoscopy. *Endoscopy*, 10(02): 127–130.

https://doi.org/10.1055/s-0028-1098280

34. Gao Q, Guo L, Wang B, 2020, The pathogenesis and prevention of port-site metastasis in gynecologic oncology. *Cancer Manag Res*, 12: 9655–9663.

https://doi.org/10.2147/CMAR.S270881

35. Lee BR, Tan BJ, Smith AD, 2005, Laparoscopic port site metastases: Incidence, risk factors, and potential preventive measures. *Urology*, 65(4): 639–644.

https://doi.org/10.1016/j.urology.2004.09.067

36. Wei L, Hussein AA, Ma Y, *et al*., 2019, Accurate quantification of residual cancer cells in pelvic washing reveals association with cancer recurrence following robot-assisted radical cystectomy. *J Urol*, 201(6): 1105–1114.

https://doi.org/10.1097/JU.0000000000000142

37. Rekhraj S, Aziz O, Prabhudesai S, *et al*., 2008, Can intra-operative intraperitoneal free cancer cell detection

techniques identify patients at higher recurrence risk following curative colorectal cancer resection: A meta-analysis. *Ann Surg Oncol*, 15(1): 60–68.

https://doi.org/10.1245/s10434-007-9591-5

38. Lécuru F, Agostini A, Camatte S, *et al*., 2002, Impact of pneumoperitoneum on tumor growth. *Surg Endosc*, 16(8): 1170–1174.

https://doi.org/10.1007/s00464-001-9226-z

39. Bouvy ND, Marquet RL, Jeekel H, *et al*., 1996, Impact of Gas(less) laparoscopy and laparotomy on peritoneal tumor growth and abdominal wall metastases. *Ann Surg*, 224(6): 694–701.

https://doi.org/10.1097/00000658-199612000-00005

40. Ramirez PT, Wolf JK, Levenback C, 2003, Laparoscopic port-site metastases: Etiology and prevention. *Gynecol Oncol*, 91(1): 179–189.

https://doi.org/10.1016/s0090-8258(03)00507-9

41. Rané A, Eng MK, Keeley FX, 2008, Port site metastases. *Curr Opin Urol*, 18(2): 185–189.

https://doi.org/10.1097/MOU.0b013e3282f4ab73

42. Paolucci V, Schaeff B, Schneider M, *et al*., 1999, Tumor seeding following laparoscopy: International survey. *World J Surg*, 23(10): 989–995.

https://doi.org/10.1007/s002689900613

43. Sooriakumaran P, Kommu SS, Anderson C, *et al*., 2009, Port-site metastasis after laparoscopic surgery: What causes them and what can be done to reduce their incidence? *BJU Int*, 103(9): 1150–1153.

https://doi.org/10.1111/j.1464-410X.2009.08363.x

44. Otsuka I, 2019, Cutaneous metastasis after surgery, injury, lymphadenopathy, and peritonitis: Possible mechanisms. *Int J Mol Sci*, 20(13): 3286.

https://doi.org/10.3390/ijms20133286

45. Brownstein MH, Helwig EB, 1972, Patterns of cutaneous metastasis. *Arch Dermatol*, 105(6): 862–868.

https://doi.org/10.1001/archderm.1972.01620090034008

46. Chaitanya SA, Kumar AA, Dalakoti P, *et al*., 2021, Dermal metastases in oral cancer after curative treatment: A single institution cohort study. *Br J Oral Maxillofac Surg*, 59(7): 814–819.

https://doi.org/10.1016/j.bjoms.2021.02.026

47. Pitman KT, Johnson JT, 1999, Skin metastases from head and neck squamous cell carcinoma: Incidence and impact. *Head Neck*, 21(6): 560–565.

https://doi.org/10.1002/(sici)1097-0347(199909)21:6<560::aid-hed10>3.0.co;2-q

48. Yang Y, Chen R, Zhang R, 2020, Cutaneous metastasis of a colon adenocarcinoma presenting as an unusual manifestation: A report of one case. *Int J Clin Exp Pathol*, 13: 1897–1901.

49. Sepilian V, 2003, Iatrogenic endometriosis caused by uterine morcellation during a supracervical hysterectomy. *Obstet Gynecol*, 102(5): 1125–1127.

https://doi.org/10.1016/s0029-7844(03)00683-5

50. LaCoursiere DY, Kennedy J, Hoffman CP, 2005, Retained fragments after total laparoscopic hysterectomy. *J Minim Invasive Gynecol*, 12(1): 67–69.

https://doi.org/10.1016/j.jmig.2004.12.021

51. Seidman MA, Oduyebo T, Muto MG, *et al*., 2012, Peritoneal dissemination complicating morcellation of uterine mesenchymal neoplasms. *PLoS One*, 7(11): e50058.

https://doi.org/10.1371/journal.pone.0050058

52. Nezhat C, Kho K, 2010, Iatrogenic myomas: New class of myomas? *J Minim Invasive Gynecol*, 17(5): 544–550.

https://doi.org/10.1016/j.jmig.2010.04.004

53. Murji A, Scott S, Singh SS, *et al*., 2019, No. 371-morcellation during gynaecologic surgery: Its uses, complications, and risks of unsuspected malignancy. *J Obstet Gynaecol Can*, 41(1): 116–126.

https://doi.org/10.1016/j.jogc.2018.07.016

54. Yu XF, Ma YY, Hu XQ, *et al*., 2014, Analysis of exfoliated gastric carcinoma cells attached on surgical supplies. *Onco Targets Ther*, 7: 1869–1873.

https://doi.org/10.2147/OTT.S66412

55. Berger-Richardson G, Xu RS, Gladdy RA, *et al*., 2018, Glove and instrument changing to prevent tumour seeding in cancer surgery: A survey of surgeons' beliefs and practices. *Curr Oncol*, 25(3): e200–e208.

https://doi.org/10.3747/co.25.3924

56. Caudill AR, Newman A, Davison SP, 2020, Precaution costs: The presumption of breast cancer seeding and its impact on surgical expenditure. *Plast Reconstr Surg Glob Open*, 8: e2903.

https://doi.org/10.1097/GOX.0000000000002903

57. Nash SC, Ketcham AS, Smith RR, 1962, Effect of local irrigation with proflavine hemisulfate on wounds seeded with tumor cells an experimental study. *Ann Surg*, 155(3): 465–471.

https://doi.org/10.1097/00000658-196203000-00023

58. Tai YS, Abente FC, Assalia A, *et al*., 2006, Topical treatment with oxaliplatin for the prevention of port-site metastases in laparoscopic surgery for colorectal cancer. *JSLS*, 10(2): 160–165.

59. Zhuang B, Chen T, Xiao Z, *et al*., 2020, Drug-loaded implantable surgical cavity-adaptive hydrogels for prevention of local tumor recurrence. *Int J Pharm*, 577: 119048.

https://doi.org/10.1016/j.ijpharm.2020.119048

60. Sun J, Zhu Y, Peng Y, *et al*., 2018, Safety and efficacy of dehydrated ethanol soaking of the operative field in the treatment of spontaneous hepatocellular carcinoma rupture. *World J Surg Oncol*, 16(1): 86.

https://doi.org/10.1186/s12957-018-1390-x

61. Boutin C, Rey F, Viallat JR, 1995, Prevention of malignant seeding after invasive diagnostic procedures in patients with pleural mesothelioma. *Chest*, 108(3): 754–758.

https://doi.org/10.1378/chest.108.3.754

62. Ito F, Camoriano M, Seshadri M, *et al*., 2011, Water: A simple solution for tumor spillage. *Ann Surg Oncol*, 18(8): 2357–2263.

https://doi.org/10.1245/s10434-011-1588-4

63. Terzi C, Ünek T, Sağol Ö, *et al*., 2006, Is rectal washout necessary in anterior resection for rectal cancer? A prospective clinical study. *World J Surg*, 30(2): 233–241.

https://doi.org/10.1007/s00268-005-0300-x

64. Okoshi K, Kono E, Tomizawa Y, *et al*., 2020, Can rectal washout reduce anastomotic recurrence after anterior resection for rectal cancer? A review of the literature. *Surg Today*, 50(7): 644–649.

https://doi.org/10.1007/s00595-019-01825-6

65. Schneider C, Jung A, Reymond MA, *et al*., 2001, Efficacy of surgical measures in preventing port-site recurrences in a porcine model. *Surg Endosc*, 15(2): 121–125.

https://doi.org/10.1007/s004640010069

66. Tsivian A, Sidi AA, 2003, Port site metastases in urological laparoscopic surgery. *J Urol*, 169(4): 1213–1218.

https://doi.org/10.1097/01.ju.0000035910.75480.4b

67. Lago V, Gimenez L, Matute L, *et al*., 2019, Port site resection after laparoscopy in advance ovarian cancer surgery: Time to abandon? *Surg Oncol*, 29: 1–6.

https://doi.org/10.1016/j.suronc.2019.01.007