

(Carcinoma of the colon, carcinoma of the rectum, carcinoma of the large bowel)**DEFINITION**

1. Cancer is a term which embraces a large number of different diseases, the common feature of which is a malignant tumour. This is a growth (neoplasm) which is not circumscribed but which infiltrates the surrounding tissues and metastasises (spreads to other sites in the body), thereby producing secondary deposits. Any tissue in the body may be affected.
2. Cancers are classified according to the tissue of origin. **Carcinoma** arises from epithelial tissue and **sarcoma** from connective tissue. The suffix **blastoma** implies a tumour of embryonic origin.
3. Cancers of the colon and rectum are usually considered together. This is because many tumours are sited at the rectosigmoid junction, which makes the allocation of tumour type arbitrary. There are also recognised difficulties in distinguishing them in mortality statistics as death is often certified simply as due to a cancer of the large bowel. The tumours are thought to be distinct in aetiology.
4. Tumours of the colon and rectum may also be benign. The importance of benign large bowel tumours (commonly known as polyps) is their ability to undergo neoplastic change. Different types of polyp are recognised, namely inflammatory, heterotopic, hamartomas and adenomas. It is, thus, critically important to distinguish adenomas from the other types of polyp.
5. The World Health Organisation divides adenomas into three types, namely tubular, villous and tubulovillous. These different types have specific histopathological features but all share, to a different degree, the capacity to become increasingly dysplastic and, ultimately, frankly malignant.
6. Most cancers of the colon or rectum are adenocarcinomata. These may be polypoid or sessile, ulcerated or non-ulcerated.
7. Certain special histological forms of adenocarcinomas of the colon and rectum are recognised. These include mucinous or colloid adenocarcinoma, adenosquamous carcinoma and small cell or undifferentiated carcinoma.
8. Carcinoid tumour may occur in the colon or rectum. At these sites, these tumours show a wide spectrum of malignant potential and a variable capacity to secrete ectopic hormones.

CLINICAL MANIFESTATIONS

9. The symptoms and signs of carcinoma of the colon and rectum vary with the site of the lesion which in about 60% of cases is in the sigmoid colon. About 20% of colonic tumours occur in the right side of the colon. In the rectum tumours are found equally in the upper, middle and lower segments.

10. The symptoms may include abdominal pain, change of bowel habit, secondary anaemia, and tenesmus with the passage of blood and/or mucus. Partial or complete obstruction of the bowel may occur.
11. Direct spread to adjacent structures is common and distant metastases may arise via the lymphatics or blood stream. Most commonly the tumours metastasise to the liver. Other sites include lungs, adrenals and brain. The disease may be advanced before it is recognised, and the development of metastases may cause the presenting symptoms.

Characteristics of neoplasia

12. Tumours arise when tissue growth becomes insensitive to normal control mechanisms. Usually cells multiply in response to a reduction in tissue cell density, the process ceasing when normal tissue architecture is restored. Tumours arise from a common ancestral cell which – years before clinical disease becomes apparent – begins to reproduce inappropriately. Malignant transformation results from mutation in the cell's genetic material.
13. These genetic mutations change the amount or the activity of the protein product. Two particular gene classes play major roles in triggering cancer. Normally **proto-oncogenes** encourage cell growth and reproduction: **tumour suppressor genes** oppose it. Mutated proto-oncogenes become **carcinogenic oncogenes**, driving excess cell multiplication. Inactivated tumour suppressor genes contribute to cancer by depriving the cell of its braking system. For cancer to develop, mutations need to occur in several of the original cell's growth control genes.
14. Cells insensitive to growth control generate, within tissues, subpopulations of cells whose subsequent progress depends on selection pressure, favouring the emergence of cells with the greatest growth potential. It is this process which determines the histology of a tumour and its clinical course. Tumour cells usually retain the characteristics of their tissue of origin. However, tissue differentiation involves the synthesis of molecules not essential to cell survival and so loss of the parent tissue markers may confer growth advantage. Dedifferentiation in a tumour implies high growth rate and high malignancy. Tumours can also metastasise (migrate via the lymph or blood stream) to other parts of the body, producing **metastatic** deposits.

AETIOLOGY

General risk factors for all cancers

15. Much is now understood about the origins and mechanisms of cancer in general, but the precise causes of individual tumours often remain unknown.

Age

16. Some risk of cancer occurs at every age, but the risk for particular types varies at different ages. Most commonly there is a progressive increase in incidence from childhood to old age (cancers of the skin, lung, gastrointestinal and genitourinary tracts, multiple myeloma and chronic lymphatic leukaemia). The rate of increase is typically proportional to the 4th or 5th power of age. Less commonly there may be a peak in early life, with decline thereafter to zero, e.g. retinoblastoma or nephroblastoma.

Gender

17. The incidence of cancer in relation to gender is not straightforward and it is changing – probably due to lifestyle and occupational changes. At the beginning of the last century overall cancer was more common in women due to the frequency of cancer of the cervix and the rarity in both men and women of cancer of the lung. Now, in developed countries, cancer is more common in men.

Latent period

18. There is a delay between initial exposure to carcinogen and clinical disease. With short intense exposures, e.g. to ionising radiation at Hiroshima, solid tumours increase in incidence for 15-20 years. Incidence may then continue to rise, level off or decline, depending on the tumour type. For acute leukaemia there is peak incidence at about 5 years, and very few cases appear after 30 years. Short intense exposure to carcinogens is exceptional and, where exposure is chronic and prolonged, e.g. due to occupation, smoking or sunlight, cancer incidence increases with exposure duration. Precisely how this operates and how subsequent risk is affected by removal from the exposure is unknown.
19. Clinical cancer is the end result of a multistage process involving initiating and promoting agents. If the carcinogen is an initiating agent, e.g. asbestos, rather than a substance influencing a later stage nearer clinical manifestation, e.g. cigarette smoking, cancer incidence in the population may continue to rise, albeit more slowly, for a considerable time after exposure to the carcinogen has ceased.

Risk factors in the individual case of all cancers

20. The main factors that determine whether a particular individual develops cancer relate to constitution and exposure to environmental factors.

Genetics

21. The close connection between certain chromosomal abnormalities associated with recognised clinical syndromes and subsequent tumour development, e.g. polyposis coli and cancer of the large bowel, and xeroderma pigmentosum and skin tumours, confirms that an individual's genetic make-up has an effect on his susceptibility to cancer.

22. Many studies have looked at cancer rate in the families of individuals with the disease. There appears to be no material tendency for cancer in general to cluster in families, and no genes have been identified that increase the risk of cancer in all tissues. However, all common cancers do cluster in families to some extent – the risk of a sibling of a patient developing a tumour at the same site is twice normal. This might be due to genetic susceptibility but could equally reflect lifestyle, e.g. diet, hygiene or a common legacy of infections in early life.

Environmental factors

23. Our knowledge of the environmental causes of cancer relies on animal laboratory investigation and human epidemiology, with the two approaches complementing each other. Since there are features common to most cancers, there are factors which can cause cancer at all or many sites. Present evidence confirms the importance of life-style factors in cancer causation.

Tobacco smoke

24. Cigarette smoking is thought to cause 30% of all cancer deaths and has been conclusively linked to cancer of the lung, upper respiratory tract, oesophagus, bladder, stomach, liver, kidney and chronic myeloid leukaemia. It may also cause cancer of the colon and the rectum. Relevant factors include number of cigarettes smoked, tar content, age at smoking onset and duration of habit.

Diet

25. There is good evidence that some common cancers would be less common if diet were modified. Animal fat consumption, particularly red meat, high salt intake and ingestion of very hot beverages and food, have all been linked to specific cancers. Similarly what is **not** in the diet may be important. Low consumption of vegetables and fruit, in the presence of high calorie intake, is associated with several different tumour types, e.g. childhood obesity and cancer of the breast and prostate, adult obesity and endometrial cancer. Consumption of alcohol (particularly along with cigarettes) increases the risk of cancer of the upper respiratory and digestive tracts. There is evidence that as little as two drinks a day may contribute to breast, colonic and rectal cancer. In total, diet is considered to account for 30% of all cancer mortality in developed countries, alcohol for a further 3%, and a salt for 1%

Radiation

26. Radiation is difficult to avoid and, in total, radiation of all types causes 2% of all cancer deaths. Most of these deaths result from natural sources, particularly sunlight, UVB.
- **UVB radiation** causes 90% of all skin cancers, including basal cell cancers, malignant melanoma and squamous cell carcinoma.
 - **Electromagnetic radiation** as a cause of cancer has been the subject of several recent studies. The results are confusing and inconsistent and reported associations may not be causal. It is of two main types:

- I. **Extremely low frequency fields**, e.g. power lines and household appliances. Basic science confirms that these radiations are of too low frequency to initiate cancer causing genetic mutation as they are of insufficient energy to ionise molecules.
- II. **Radiofrequency electromagnetic radiation**, e.g. cellular telephones, microwaves and living creatures. Although more energetic than I. (above), they are still unable to cause molecular ionisation.

In conclusion at this date there is no good scientific evidence that electromagnetic radiation causes cancer. Any possible association remains hypothesis.

- **Ionising radiation**

Ionising radiation can penetrate animal tissues and damage DNA and theoretically has the power to produce cancer in most tissues. The actual risk due to exposure to ionising radiation may, however, be different. It is often overestimated and not evidence-based. Amongst Japanese residents of Hiroshima and Nagasaki who survived more than a year after detonation, only 1% have died of tumours.

Studies of humans exposed to high dosage of ionising radiation, e.g. the Japanese atomic bomb survivors, or individuals medically irradiated for tumours, have shown an increased incidence of cancer due to that exposure. There is, however, no firm evidence from human low-dose epidemiological studies which unequivocally demonstrates an increase in cancer incidence. This may be due to the very large size of study population which would be needed to demonstrate an increased incidence.

For radiation protection purposes it is, therefore, accepted that there is no threshold level below which no carcinogenic effect is produced and the risk of a cancer developing is extrapolated on a dose-proportional basis from high to low doses and dose rates. All humans are constantly exposed to ionising radiation from both the natural environment and man-made products. The natural sources include cosmic radiation from space, radiation from the ground and from inhaled and ingested materials. Air travel and mining both increase exposure to background radiation. Radiation originating in the body comes mainly from potassium, while lungs are exposed through radon in inhaled air. Man-made radiation comes from medical uses, past atomic tests, man-made products and radioactive waste.

Natural radiation differs depending on location. In the UK the average annual dose is less than 2,000 microsieverts. There is however, a considerable range; it may rise to 8,000 microsieverts in some areas and to 100,000 in some homes. The UK average annual dose from man-made sources in total is less than 300 microsieverts and, again, there may be variation.

From 1952 to 1958 the UK carried out 21 atmospheric nuclear tests in the Pacific Ocean. The locations were chosen because of their isolation and low natural radiation level. On average the Christmas Island annual background radiation is less than 700 microsieverts.

Radiation dose

27. The effects of ionising radiation depend on the exposure size of the accumulated dose. A discussion of radiation dose is at Annex A.

Therapeutic drugs

28. About 20 agents, not all of which are in current use, are known to cause cancer. Potential carcinogens may still be used if the hazard is judged to be less than the chance of saving a life, e.g. certain cancer drugs. Close scrutiny is kept on drug hazards and the position of oestrogens in hormone replacement therapy (HRT) – known to cause endometrial cancer – and of the oral contraceptive pills – which have been associated with carcinoma of the cervix, breast and hepatoma – is closely monitored. Together, prescribed drugs are held responsible for less than 1% of all fatal cancers.

Occupation

29. Historically, study of occupational exposures has identified many important carcinogens. Material or process modification and, latterly, health and safety statute have removed many potential hazards in the developed world. However, the long latent period of cancer means that a considerable time will be required for the effects of industrial carcinogens to be eliminated and, equally, that new hazards may remain unsuspected for a long time. At present overall, occupation is considered responsible for 2-3% of all fatal cancers in developed countries. Particularly important occupational carcinogens are asbestos dust exposure, exposure to combustion products of fossil fuels and ionising radiation.

Pollution

30. Investigation of the relation between environmental pollution – air, soil and water – and cancer is difficult because of the widespread nature of pollution and similar risk to people over a wide geographical area. It is generally accepted that, in the UK at the beginning of the last century, air pollution via combustion may have contributed to a few percent of lung cancers. Over the last 30 years, with increasing statute on pollution reduction, this has become much less common. Advances in chemical analysis have allowed recent interest in pollution of soil and water as possible cancer risks.
31. Another complicating factor in accurately attributing risk of cancer to individual external agents is **interaction**. Some carcinogenic agents act together to produce effects much greater than the sum of the separate individual effects, e.g. smoking and asbestos in relation to cancer of the lung, smoking and alcohol in relation to carcinoma of the oesophagus, and aflatoxin and hepatitis B infection in cancer of the liver.

Specific risk factors for cancer of the colon and rectum

32. Malignant disease of the large bowel was responsible for 16,500 male deaths in England and Wales in 1987 and is now second only to lung cancer as the most common cause of cancer deaths. Colorectal cancer is not uniformly distributed among all populations. The highest incidences are in North America and Western Europe – intermediate rates are seen in Eastern Europe, and the lowest rates are found in Asia, Africa and South America (except Argentina). The incidence of rectal cancer appears to vary less geographically than colonic cancer. In high risk countries there are notable regional differences. In the US, colorectal tumours predominate in the north-east, and are more common where there are large populations, high income and high levels of education.
33. The incidence of colorectal cancer increases with age. Both rectal and colonic tumours are most common in the decade 60-69 years. The gender distribution of colorectal cancer in developed countries is approximately equal. However, when cancers of the colon and rectum are assessed separately, certain differences emerge. In the UK, cancer of the colon has a male:female ratio of 2:3, and for cancer of the rectum 8:7.
34. Despite advances in understanding, the aetiology of colorectal carcinoma is not completely understood.
35. The conditions are common in sophisticated societies. The explanation for this is not purely genetic as migrants moving from low to high incidence areas become at greater risk of developing the disease. No occupational hazard for colorectal cancer has been identified, nor is there any relation to socio-economic class. Some studies have, in the past, reported an increased risk in people exposed to asbestos. However, it is now agreed that this spurious association arose from misdiagnosis of peritoneal mesothelioma and bronchial metastatic tumour. Because there is evidence that diet correlates well with the geographic variations of the disease, investigation has turned to investigation of dietary factors.
36. The exact nature of the dietary link, however, remains unknown. Different studies have focussed on lack of vegetables, high sugar intake and excess alcohol as causal, but results have been conflicting. There is some suggestion that coffee may be protective. Work is presently in progress on the role of bile acids – which may be causal via direct toxic action on the colonic mucosa or following conversion into a carcinogen.
37. Cancer of the large bowel may arise in patients with longstanding extensive ulcerative colitis. The more extensive the disease, the greater the risk. The relation to Crohn's disease is more tenuous. The balance of opinion is that there is a risk, but that it is much lower than for ulcerative colitis.
38. Similarly, although the chronic infections (amoebiasis, tuberculosis and syphilis) produce tumour-like granulomas, none of these, and no other infection, has been shown to lead to cancer. Colorectal cancer may also occur in those with surgical implantation of the ureters into the sigmoid colon. In such patients the malignant change occurs about 20 years after implantation.

39. Benign polyps, which may be multiple, are common in the large bowel. In developed countries cancers of the large bowel arise in adenomas. In familial conditions with multiple polyps, for example, familial adenomatous polyposis and Gardner's syndrome, malignant change is almost the rule before middle age.
40. In the last few years evidence has been emerging from molecular biology and genetics that there are patients – other than with familial adenomatous polyposis – who have a hereditary predisposition to develop large bowel cancer. This group is usually described as suffering from hereditary non-polyposis cancer. Two main syndromes are described both with dominant inheritance.
41. Excess ionising radiation exposure appears to be causally linked to colorectal cancer. Several case series of patients who received pelvic irradiation for cancer of the cervix show later development of colorectal cancer. However, it must be remembered that all patients with gynaecological malignancy appear to be at high risk of developing colorectal cancer, irrespective of ionising radiation. There is additional evidence for a link where ionising radiation has been given for menorrhagia / ankylosing spondylitis. Dose levels may be important as most of the published reports refer to patient cohorts irradiated many years ago, when doses of therapeutic irradiation were high – typically 50-65 Sv (sieverts) in divided doses.
42. The Radiation Effect Research Foundation studies of atomic bomb survivors shows a conclusive link between cancer of the colon and exposure to ionising radiation.
43. Cancer of the colon and rectum has not been shown to be caused by climatic extremes, trauma, physical or mental stress or lowered resistance arising from hardship or other diseases. There is no evidence that its progress is dependent on external factors other than medical treatment.

CONCLUSION

44. Cancer of the colon and rectum is a common malignant tumour. Some cases of cancer of the colon are wholly genetically determined. Some diseases and surgical procedures predispose to cancer of the large bowel. Apart from those discussed above, no specific aetiological external factors have been identified. There is no evidence that the course of the condition is affected by environmental factors other than those involved in its treatment.

REFERENCES

Boice J D. Studies of Atomic Bomb Survivors. JAMA 1990;264:622-623.

Darby, S C, Kendall GM, Fell T P et al. A summary of mortality and incidence of cancer in men from the United Kingdom who participated in the United Kingdom's atmospheric nuclear weapon tests and experimental programmes. BMJ 1990;296:332-338.

Doll R and Peto R. Epidemiology of Cancer. In: Eds. Weatherall D J, Ledingham J G G and Warrell D A. Oxford Textbook of Medicine. 3rd Ed. 1996. Oxford. Oxford University Press. 4.95-4.123.

Doll R. Epidemiology of Human Neoplasia. In: Eds. McGee J O'D, Isaacson P G and Wright NA. Oxford Textbook of Pathology. 1992. Oxford. Oxford University Press. 679-694.

Harnden D G, Lorenzen J, Pusztai L and McGee J O'D. Carcinogenesis. In: Eds. McGee J O'D, Isaacson P G and Wright N A. Oxford Textbook of Pathology. 1992. Oxford. Oxford University Press. 633-678.

Pierce D A et al. Studies of the mortality of atomic bomb survivors. Report 12, part 1. Cancer: 1950-1990. Rad Res. 1996;146:1-27.

Schimizu Y, Schull W J and Kato H. Cancer risk among Atomic Bomb Survivors: the RERF Life Span Study. JAMA 1990;264:601-604.

Thompson D E et al. Cancer incidence in atomic bomb survivors Part II: Solid Tumours, 1958-1987. Rad. Res. 1994;137:S17-67.

Williams et al. Colorectal tumours. In: Eds. Peckham M et al. Oxford Textbook of Oncology. 1st Ed. 1995. Oxford University Press. 7.4:1133-1167.

March 2000

Radiation dose

1. The first definition of a unit of radiation dose was made in 1928 by the International Congress of Radiology. The roentgen (R) was defined as that quantity of radiation which produces in 1 cm of air one unit of charge of either sign, thus defining a unit of exposure. Units of **absorbed dose**, the actual energy absorbed in the tissue being irradiated are now used. The radiation absorbed dose or **rad** is now cited in SI (Système Internationale) units – joules per kg – of absorbing material. The fundamental unit, 1 joule/kg, is 1 gray (1 Gy), equivalent to 100 rads (R).
2. Different radiation types have greater or lesser effect per unit dose, so they are all expressed relative to the effects of X-rays, ie. a unit equivalent dose is used. To calculate the roentgen equivalent in man (**rem**), the absorbed radiation dose is multiplied by a radiation weighting factor, dependent on type and energy of the radiation. The current SI unit of equivalent dose is the **Sievert**. For X-rays and gamma rays the equivalent dose in sieverts and the absorbed radiation dose in grays are the same. The relationship between the different dose units is:-

1 gray (Gy) = 1 joule/kg = 100 rads (R) = 100 rems (r) = 1 sievert (Sv) = 1,000 millisieverts (mSv) = 1,000,000 microsieverts (microSv). Typical doses of radiation include:

Chest X-ray – 0.02 mSv

Brain scan – 7 mSv

Bone scan – 4 mSv

Average annual UK dose from cosmic rays – 0.26 mSv

Average annual UK dose from gamma rays – 0.35 mSv

Average annual UK dose from natural background radiation – 2.2 mSv

3. Effects of total body irradiation

Equivalent dose (Sv)	Effect
Sub lethal to man 0.0001 (0.1 mSv)	Around 2 weeks' natural background radiation, no detectable effect
0.001 (1 mSv)	Around 6 months' natural background radiation, no detectable effect
0.01 (10 mSv)	No detectable effect
0.1 (100 mSv)	Minimal decrease in peripheral lymphocyte count, no clinical effect
1 (1000 mSv)	Mild acute radiation sickness in some individuals (nausea, possible vomiting), no acute deaths, early decrease in peripheral lymphocyte count, decrease in all WBC and platelets at 2-3 weeks, increase in late risk of leukaemia, solid tumours

Equivalent dose (Sv)	Effect
Lethal to man 10 (10,000 mSv)	Severe acute radiation sickness, severe vomiting, diarrhoea, death within 30 days of all exposed individuals. Severe depression of blood cell and platelet production, damage to gastrointestinal mucosa.
100 (100,000 mSv)	Immediate severe vomiting, disorientation, coma, death within hours
1000 (1,000,000 mSv)	Death of some micro-organisms, some insects within hours
10,000 (10,000,000 mSv)	Death of most bacteria, some viruses
100,000 (100,000,000 mSv)	Death of all living organisms, denaturation of proteins

Radiation dose limits

4. Since the days of Marie Curie it has been appreciated that ionising radiation exposure may be hazardous to health. Radiation dose limits were first recommended for ionising radiation exposure in 1928. The statutory limit on the amount of radiation to which the general public may be exposed in excess of natural background radiation and excluding medical exposure is set, from 1 January 2000, at 1 mSv per annum.
5. The most important source of man-made exposure is medical investigation which accounts for 90% of man-made exposure. Average natural background radiation is raised to 2.6 mSv by all man-made exposure. UK estimated exposure, excluding medical investigation, is 0.04 mSv. Other statutory limits include occupational dose limits. From 1 January 2000, these are 20 mSv per annum for classified workers and 6 mSv per annum for unclassified workers.

January 2000