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MALIGNANT DISEASE OF THE PARANASAL SINUSES AND NASAL CAVITY*

IMPORTANCE OF PRECISE LOCALIZATION OF EXTENT OF DISEASE

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BECAUSE of the proximity of such vital structures as the eyes and brain and complex anatomic relationships of the areas involved, cancers of the paranasal sinuses and nasal cavity require greater than usual precision in localization of the disease. The skill with which this localization is performed is a major factor in determining both survival and the incidence of complications. It is characteristic for these tumors to progress to an advanced stage while remaining localized with infrequent lymph node or distant metastases.[26] The local recurrence rate (36 per cent in this series), therefore, underscores the frequent failure to achieve and maintain local control of these neoplasms[22] despite the combined use of radiotherapy and surgery in many cases.[10,13,17]

Whether the tumor originates in the nasal cavity or in one of the sinuses, spread to surrounding structures is the rule by the time the patient presents for treatment.[20,21] Identification of the specific site of origin can be difficult or impossible when the disease is advanced.[25] The roentgenographic examination is the most accurate clinical technique for establishing the origin and routes of spread of these lesions.[3,12,15] In order to secure the maximum information as to the extent of these neoplasms, we have obtained roentgenograms in the following views:[3,7]

(1) Caldwell's, Waters's, and lateral views of the paranasal sinuses using the Potter-Bucky diaphragm and small cones.

(2) Two submentovertical views, the second view being obtained with increased cephalic angulation of the tube to displace the image of the mandible anteriorly and to avoid superimposition of the posterolateral wall of the maxillary sinus and orbital surface of the greater sphenoid wing.

(3) Frontal tomograms at 1 cm. intervals from 2 to at least 9 cm. from the tabletop with the patient prone and the cantho-meatal line perpendicular to the table.

(4) Lateral and transverse tomograms, and, in selected cases, positive contrast studies of the sinuses[8] and of the nasopharynx[14] are of value.

The tomograms are especially useful in realizing a three-dimensional concept of the extent of disease;[16,24] also, bone erosion is more easily detected in the absence of superimposed obscuring densities.[7] Although roentgenographic identification of bone erosion is not pathognomonic of malignant disease, its discovery requires intensive investigation to determine its cause, which, in most cases, will prove to be cancer.

SITES OF ORIGIN AND ROUTES OF SPREAD

A number of systems of classification of antral carcinomas have been advanced.[5,19,23] We have followed Baclesse[1] in dividing

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antral lesions according to sites of origin as determined by roentgenographic studies.

Certain patterns of disease extension characterize malignant disease arising in these different sites:[2,3]

(1) *Maxillary sinus.*

A. Infrastructure, below the level of the inferior surface of the middle turbinate (Fig. 1, *A* and *B*). Tumors arising here can be confused with those originating in the upper gum as they may extend into the hard palate, alveolar process or gingivobuccal sulcus and be seen during the examination of the mouth. Extension may also occur into the soft tissues of the cheek below the zygoma, nasal cavity, and in rare instances into the pterygoid plates and pterygopalatine space.

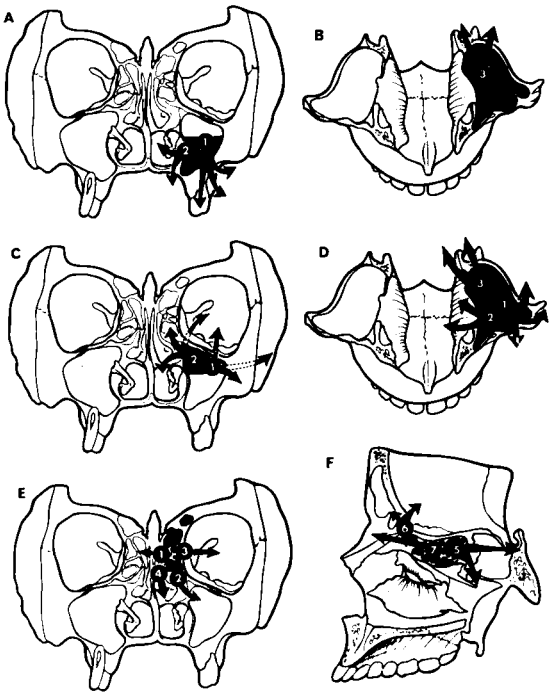

FIG. 1. Routes of spread of paranasal sinus carcinomas.

(*A* and *B*) Antral infrastructure origin: (1) Into the alveolar process, gingivobuccal sulcus and soft tissues of the cheek below the zygoma; (2) into the nasal cavity and hard palate; (3) into the pterygoid plates and pterygopalatine space.

(*C* and *D*) Antral suprastructure origin: (1) into the zygoma, posterolaterally into the infratemporal fossa, and into the orbit; (2) into the nasal cavity, ethmoid sinuses and orbit; (3) into the pterygopalatine space and base of skull. This occurs more commonly than it does in infrastructure lesions.

(*E* and *F*) Ethmoid sinus origin: (1) Into contralateral ethmoid sinuses; (2) into the antrum with erosion of the ethmoidomaxillary plate; (3) into the orbit; (4) into the nasal cavity with invasion of the septum and turbinates; (5) into the sphenoid sinus, nasopharynx and base of the skull; (6) into the frontal sinus, cribriform plate and anterior cranial fossa; (7) forward into the frontonasal angle.

B. Suprastructure, above the level of the inferior surface of the middle turbinate (Fig. 1, *C* and *D*). These tumors frequently extend superiorly and medially into the orbit, ethmoid sinuses, and nose; laterally into the zygoma and posterolaterally into the infratemporal fossa; and posteriorly into the pterygopalatine space and base of skull.

C. Additional specific sites:

(a) Ethmoidomaxillary. This site contains a highly malignant group originating in the region of the ethmoidomaxillary plate which separates the ethmoid region from the superomedial portion of the antrum. The tumors involve the antrum and ethmoid from the onset and extend rapidly through the medial wall of the orbit and medial portion of the orbital floor.

(b) Endosinus. These tumors spread diffusely within the mucosal lining of the antrum without bone erosion initially when the tumor breaks through the bony walls; spread occurs virtually simultaneously in all directions.

(c) Medial wall. Tumors originating in the medial or nasal-antral wall mimic primary nasal tumors in their routes of spread.

(2) *Ethmoid sinuses* (Fig. 1, *E* and *F*). Neoplasms may originate in the anterior, middle, or posterior sinuses, but

extension throughout the ethmoid region on the side of involvement is usually present when the patient is first seen. Because of the central location of the ethmoid sinuses, extension of tumor often involves all of the other paranasal sinuses as well as the orbit, nasal cavity, nasopharynx, and base of skull.

(3) *Frontal sinus* (Fig. 2*A*). Primary carcinomas of the frontal sinuses as well as those of the sphenoid sinuses are quite rare.[11] It is often difficult to distinguish frontal neoplasms from tumors of the ethmoid sinuses spreading upward. Frontal neoplasms may extend anteriorly into the forehead, often with secondary infection, inferiorly into the ethmoid sinuses and into the orbit, and posteriorly into the dura and frontal lobes.

(4) *Sphenoid sinuses* (Fig. 2*B*). The tumors arising in the sphenoid sinus and extending inferiorly into the nasopharynx are difficult to differentiate from primary nasopharyngeal cancer spreading superiorly. Extension may also occur through the floor of the middle cranial fossa and sella turcica as well as anteriorly into the posterior ethmoid cells and nasal cavity.

(5) *Nasal cavity*. There are three anatomic regions:

A. The vestibule is the expanded lower portion of the nasal cavity just inside the external nares. Tumors arising here are essentially skin cancers and not considered in this report.

B. Nasal cavity proper.

C. The olfactory region, a narrow strip in the apex of the nasal cavity extending a short distance onto the medial and lateral walls.

For purposes of classification, the tumors of the nasal cavity have been divided into two groups:

(1) A *superior* group which arises above the horizontal plane lying at the level of the lower border of the superior turbinate (Fig. 2, *C* and *D*). Because part of the lymphatic drainage in this region passes through the cribriform plate and unites with the lymphatics of the subarachnoid space,[18] tumors in this region may extend rather quickly to the anterior cranial fossa. Early extension also often occurs to the ethmoidal region, orbit, and superior medial antrum. Contralateral spread is less common than with ethmoidal tumors.

(2) An *inferior* group (Fig. 2, *C* and *D*) arises in the lateral wall (nasal antral septum), middle and inferior

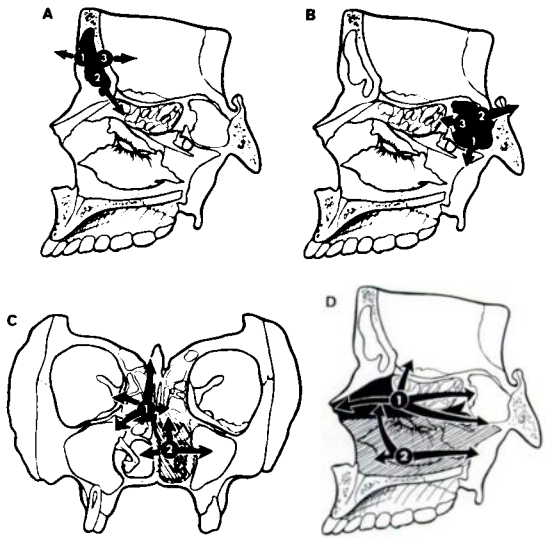

Fig. 2. Routes of spread of paranasal sinus and nasal carcinomas.

(*A*) Frontal sinus origin: (1) Anteriorly producing mass in the region of the bregma and nasion, often with secondary infection; (2) into the ethmoid sinuses and through the superior medial wall of the orbit; (3) into the dura and frontal lobes.

(*B*) Sphenoid sinus origin: (1) Into the nasopharynx; (2) through the floor of the middle cranial fossa and sella turcica; (3) into the posterior ethmoid cells and nasal cavity.

(*C* and *D*) Nasal cavity origin: (1) Into the anterior cranial fossa, ethmoid cells, orbit, antrum and commonly posteriorly into the sphenoid sinus and along the base of the skull and roof of the nasopharynx; (2) posteriorly to protrude through the posterior choana, superiorly into the upper nasal cavity and occasionally to the other side of the nose.

TABLE I

PARANASAL SINUSES—NASAL CAVITY
(1954–1963)
HISTOLOGY

	No. of Patients	Per Cent
Squamous cell carcinoma	79	65
Unclassified malignancies	17	14
Adenocarcinoma	8	7
Rhabdomyosarcoma	7	6
Fibrosarcoma	3	2.5
Esthesioneuroepithelioma	3	2.5
Miscellaneous	4	3
Total	121	100

turbinates or nasal septum. These tumors frequently extend posteriorly to protrude through the posterior choana into the nasopharynx where they may be seen by mirror examination or demonstrated by positive contrast nasopharyngography.

CASE MATERIAL

The charts and roentgenograms of 121 patients with previously untreated primary malignant disease of the paranasal sinuses and nasal cavity seen at the University of Texas M. D. Anderson Hospital and Tumor Institute at Houston from 1954 through 1963 have been analyzed. Nearly two-thirds of the lesions were squamous cell carcinomas (Table I). In 58 per cent of cases, the lesions arose in the maxillary sinus (Table II). Of these, 37 per cent originated in the infrastructure, 14 per cent in the suprastructure, and 6 per cent were ethmoidomaxillary; the remainder were so extensive that their site of origin could only be designated as the maxillary sinus. Nasal cavity and ethmoid lesions followed in that order of frequency.

Nearly equal numbers of patients were treated by surgical procedures alone, radiation therapy alone, or combined surgical and radiation therapy with the irradiation given either preoperatively or postoperatively. In general, surgical therapy was selected for patients with relatively localized disease, while combined surgical and radiation therapy was used for the more advanced lesions. Radiation therapy as the sole method of treatment was used prin-

TABLE II

PARANASAL SINUSES—NASAL CAVITY
(1954–1963)
RECURRENCES AND 5 YEAR SURVIVAL BY SITE OF ORIGIN

Origin	No. of Patients			Per Cent Recurrences	Per Cent 5 Year Survival*	
					Absolute	Determinate†
Antrum						
Infrastructure	26			15	66.7	66.7
Suprastructure	10			40	50	50
Ethmoidomaxillary	4			(50)	(0)	(0)
Massive	30			57	25.9	33.3
Over-all antrum		70		39	35.1	41.9
Ethmoid	20			45	50	50
Frontal	1			(100)	(0)	(0)
Sphenoid	2	23		(50)	(50)	(50)
Total sinuses			93	40.8	35.1	39.6
Nasal cavity			28	21.4	63.2	75
Total Series			121	36.3	42.5	48.4

* Not all cases are included in the analysis of 5 year survival; in some, an insufficient time has elapsed following treatment.
† For determinate survival, patients dying of intercurrent illnesses or lost to follow-up are excluded.

cipally for nasal cavity lesions, advanced sinus cancer treated for palliation only, and when the patient refused operation or was medically inoperable.

TREATMENT PLANNING

The paranasal sinuses and nasal cavity compose an anatomic area where the sophisticated wedge filter technique is especially useful.[6,9] It has proved helpful in preparing, from the patient's contour, a cardboard cutout with leveling device attached, to insure reproducible positioning.[9]

Because of the rounded contour of the cheek, a right angle pair of wedge filtered portals may seem to be optimal but this is rarely, if ever, used because the opposite eye is in the treatment field. Furthermore, in practice, overlapping or missing is not easy to avoid at the junction of portals at right angle (Fig. 3*A*). A dose distribution which is superior in several respects may be achieved by posterior angulation of the lateral field (Fig. 3*B*). This reduces the dose to the contralateral eye and also raises the dose posteromedially in the region of the pterygopalatine space. Care must be taken to be sure that the angulated field extends posteriorly far enough to encompass lateral disease.

For tumors originating and extending largely in the midline (ethmoid, frontal,

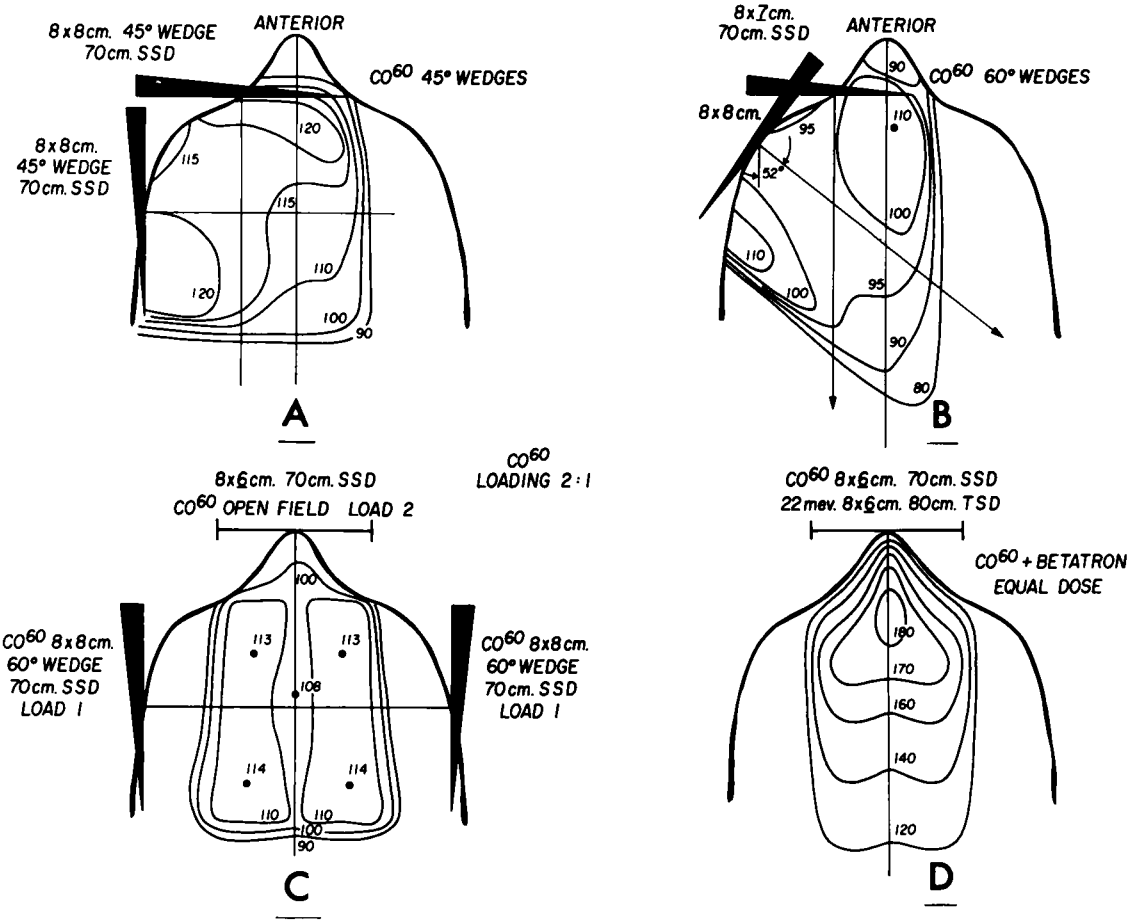

Fig. 3. (*A–D*) Various patterns of isodose distribution available for treatment of patients with nasal and paranasal sinus malignancies. For a description, see text. (From G. H. Fletcher, Textbook of Radiotherapy, Lea and Febiger, Philadelphia, 1966.)

sphenoid, nasal) an anterior open field is used. The anterior field may be L-shaped if disease has extended into a maxillary sinus. Addition of a pair of lateral wedge filtered portals yields an homogeneous dose pattern extending posteriorly as far as required (Fig. 3*C*). If disease extends far anteriorly, 6,000 rads are given through an anterior portal with dose build-up posteriorly with wedged lateral portals. Often the anterior field can be reduced near the conclusion of treatment and the additional radiation given as a "boost." High energy electrons, because of their limited depth of penetration, may be used to advantage for a portion of the anterior radiation and may be tailored to spare the underlying frontal lobes and brain stem.

In some instances, a combination of 22 mev. and cobalt 60 irradiation to an anterior field may give a satisfactory dose distribution (Fig. 3*D*).

Tumor doses are in the range of 5,000 rads in 5 weeks preoperatively, or 6,000 rads in 5 to 6 weeks postoperatively or when irradiation is used alone. An additional 500 to 1,000 rads may be given through reduced fields to sites of possible residual disease.

When orbital involvement has not been demonstrated, it is tempting to avoid irradiation of the ipsilateral eye, but this may lead to inadequate irradiation of disease.[4] The roof of the antrum rises posteromedially. Reduction in dose to disease in this region may be produced by the use of an eye shield since the antral roof often rises to the level of the cornea (Fig. 4). There is marked anatomic variation in this respect, however, and evaluation of the individual case is required. Shielding of the eye may also result in decreased dose to the floor of the middle cranial fossa and foramen rotundum. The floor of the anterior cranial fossa and ethmoidal regions may receive insufficient irradiation when the eye is shielded if these areas receive no dose contribution from the lateral field and inadequate dose from a narrow upward prolongation of the anterior field. Shielding of the homolateral eye from irradiation should be done only with great care to ensure adequate dosage to all known or probable disease extensions adjacent to the orbit.

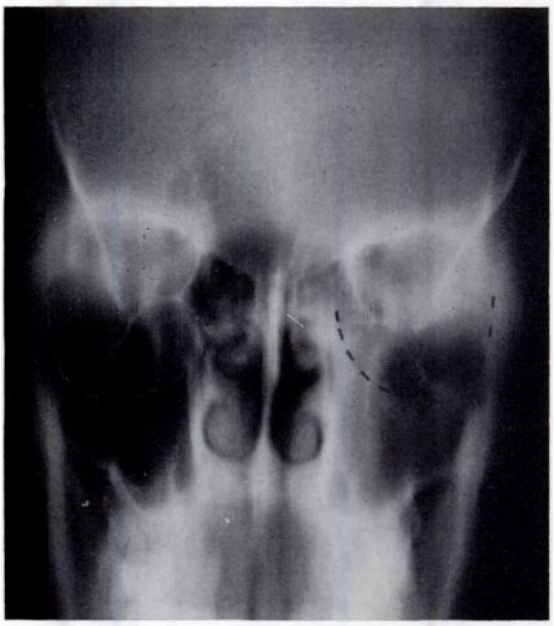

FIG. 4. Tomogram, 5 cm. posteroanterior: The lower halves of the bony orbits have been outlined by use of the 3 cm. posteroanterior tomogram. Note that approximately one-third of the right maxillary antrum projects above the inferior orbital rim. Shielding the right eye in such a case could result in inadequate irradiation of tumor if it occupied the region of the antral roof, especially medially. There is considerable variability in the degree of upward slope of the posterior antral roof, even from one side to the other in the same individual, as shown in this case.

RESULTS

An analysis of 5 year survival by site of origin (Table II) revealed that the lesions having the most favorable prognosis were those arising in the nasal cavity (75 per cent determinate 5 year survival) and in the maxillary antrum infrastructure (66.7 per cent 5 year survival). There were no survivors of the 4 cases classified as having ethmoidomaxillary tumors. The determinate 5 year survival for the entire series was nearly 50 per cent.

The survival rates for the different methods of treatment (Table III) must be

TABLE III

PARANASAL SINUSES—NASAL CAVITY
(1954–1963)
RECURRENCES AND 5 YEAR SURVIVAL BY METHOD OF PRIMARY TREATMENT

Treatment	No. of Patients	Per Cent Recurrences	Per Cent 5 Year Survival	
			Absolute	Determinate
Surgery alone	42	38	61.5	66.7
Irradiation alone	35	26	35.3	40.0
Preoperative irradiation	23	39	31.3	38.5
Postoperative irradiation	15	40	30.0	37.5
Chemotherapy alone	3	—	0	0
Chemotherapy+irradiation	2	—	0	0
No treatment	1	—	0	0
Total Series	121	36	42.5	48.4

interpreted in light of the fact that the choice of treatment was determined by the location and extent of the disease.

The recurrence rate for maxillary sinus infrastructure lesions (Table II) is significantly less than for other sites, largely because of their ready accessibility to surgical extirpation and early onset of symptoms (usually toothache and facial pain). Nasal cavity tumors also recur relatively infrequently. The recurrence rate for the total series was 36 per cent. The difference in recurrence rates among the different methods of primary treatment is not statistically significant. Furthermore, the different groups obviously do not represent comparable groups as the cases were assigned to various treatment methods according to stage and type of disease as mentioned above. It is somewhat surprising that the group treated by irradiation alone did not demonstrate a significantly higher recurrence rate, in view of the fact that many of these patients were treated at an extremely advanced stage of disease.

Of the 121 cases reviewed, the tumor remained localized in 108, of which only 13 had detectable lymph node or distant metastases at any time on follow-up. Forty-four patients with recurrent or persistent disease were studied in an effort to discover, if possible, the cause of the local failure (Table IV). These local failures reflect the difficulty in achieving local control.

In 14 patients, the tumor was so extensive that palliation was the only intent. In the remaining cases, the sites of active disease were most often at the surgical margin or the edge of treatment portals. Shielding of the eye during irradiation or failure to exenterate the orbit in the presence of immediately adjacent tumor resulted in recurrence in 9 cases.

Several illustrative cases are presented to demonstrate the pitfalls in therapy which may result in recurrences.

TABLE IV

ANALYSIS OF 44 LOCAL FAILURES IN 121 PREVIOUSLY UNTREATED MALIGNANT DISEASES OF THE PARANASAL SINUSES AND NASAL CAVITY
(1954–1963)

Radiotherapy*	
Failure of primary lesion to respond	3
Recurrence at margin of treatment field	9
Recurrence in area protected by eye shield	4
Surgery	
Recurrence at margin of resection	11
Known tumor remaining after surgery	3
Massive disease—palliation only	14
Total	44

* Alone or combined with surgery.

ILLUSTRATIVE CASES

CASE I. A squamous cell carcinoma of the right antrum with involvement of the right nasal turbinates and orbital floor in a 61 year old white female was treated by radical resection of the right maxilla without orbital exenteration. Twenty months later a recurrence developed in the right inner canthus adjacent to the previous excision. A right orbital exenteration was performed, and the patient is living without evidence of disease 6 years later.

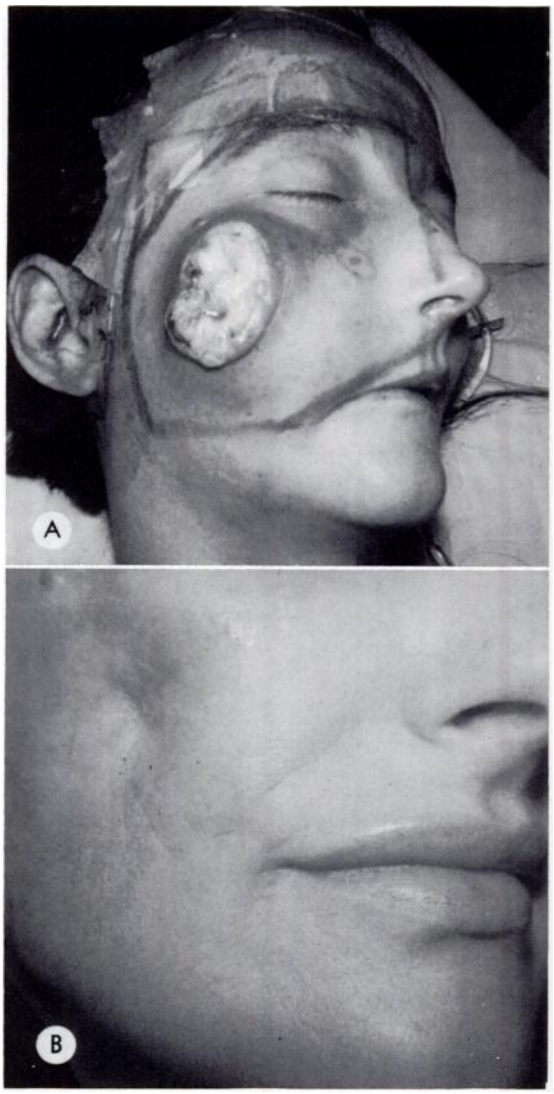

Fig. 5. (*A*) Photograph of the treatment field used for a large cheek recurrence following incomplete radiation therapy for a squamous cell carcinoma of the maxillary sinus infrastructure. Note the catheters for intra-arterial infusion of 5-fluorouracil and methotrexate. During the last half of her course of radiation therapy, the field was reduced to exclude the right eye. (*B*) Appearance of the skin 15 months after treatment of the recurrence.

CASE II. A 59 year old white male with squamous cell carcinoma of the right antrum extending into the nose received preoperatively 5,000 rads tumor dose in 5 weeks from cobalt 60 teletherapy. Anterior and right lateral 45 degree wedge filtered portals were used, with the right eye shielded from both portals. Six weeks later, a right maxillary resection without orbital exenteration was performed. Recurrent tumor developed in the cribriform plate and frontal region 18 months later. This area was not included in the lateral portal in an attempt to preserve vision, and was near the margin of the anterior field, both factors resulting in low dosage.

CASE III. A 27 year old white female with squamous cell carcinoma of the infrastructure of the right maxillary antrum was planned for 5,000 rads tumor dose preoperatively in 5 weeks to be followed by radical surgery with exenteration of the orbit. Anterior and lateral 45 degree wedge filtered portals were used with no eye shield. She did not return for the planned operation because of personal problems, but was seen 2 years later with a massive recurrence anteriorly at the junction of the 2 fields (Fig. 5, *A* and *B*). This area received a low tumor dose but was expected to be removed at operation. For the recurrent disease, she was treated with intra-arterial 5-fluorouracil and methotrexate, plus 5,000 rads given dose to an area which included the right eye during half of the dose. The patient is alive 5 years after her initial treatment, with normal vision and only moderate conjunctival infection in the irradiated eye.

CASE IV. A 54 year old white male with adenocarcinoma of the left ethmoid sinuses was treated by maxillary resection with curettement of the ethmoid sinuses and postoperative irradiation using 250 kv. roentgen rays (this patient was treated in 1954). A tumor dose of 6,100 r in 46 days was delivered through cross-firing paired anterior and lateral portals. The lateral portals were angled 20 degrees anteriorly. In spite of a small field at the bregma directed 25 degrees caudad, the dosage in the posterior ethmoid-sphenoid region was low. A

TABLE V

COMPLICATIONS IN 75 PATIENTS WITH PARANASAL SINUS AND NASAL CAVITY MALIGNANT DISEASES RECEIVING IRRADIATION*
(1954–1963)

Minor		Major	
Exposed bone of maxilla	1	Decreased vision (optic nerve atrophy, retinal or central nervous system damage)	6
Delayed healing postoperatively	4	Central nervous system necrosis (suspected or confirmed)	3
Wound abscess	2	Osteonecrosis (mandible 1, maxilla 1)	2
Epiphora	1		
Cataract	1		
Totals	9 (12%)		11 (15%)

* Total complications-20 (27%).

recurrent mass developed in this area 7 months after completion of therapy.

COMPLICATIONS

The complications encountered in 75 patients receiving irradiation alone or combined with surgical resection are enumerated in Table v. Central nervous system and ocular damage comprised the bulk of major complications. Such risks can be entirely avoided only at the cost of an increase in recurrences due to inadequate irradiation of disease.

SUMMARY

Adequate treatment for carcinomas of the paranasal sinuses and nasal cavity demands a thorough evaluation of the site of origin and routes of spread of the tumor. Roentgenographic examination is the most accurate clinical procedure for obtaining this information.

Detailed roentgenographic examinations are required in order to give the maximal amount of information with respect to the total extent of tumor involvement.

Since these lesions tend to remain localized, the problem is principally one of local control of the disease. Failure to achieve local control has been seen to reflect an initial underestimation of the extent of disease or curtailment in the radicality of the treatment technique in an effort to preserve vision or avoid the risk of complications. In some cases, failure may be due merely to the fact that the disease is so massive that only palliation can be attempted.

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