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Radiologic Evaluation of the Upper Airway Before Anaesthesia

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ABSTRACT

Airway management is a critical pillar of an aesthetic and surgical practice. Any unforeseen airway obstruction during clinical procedures can lead to severe complications, including acute hypoxia or cardiac arrest. This study aims to highlight the pivotal role of advanced medical imaging as a diagnostic and proactive tool for evaluating the complex anatomy of the upper airway and predicting potential challenges during tracheal intubation. The study adopted an analytical approach by examining clinical cases from multiple medical centres, including Al-Sadr Teaching Hospital, Al-Najaf Teaching Hospital and the National Oncology Hospital. The sample encompassed various conditions, such as structural deformities, nasal septum deviation, and laryngeal tumours. The imaging protocols utilised included Computed Tomography (CT) for its superior visualisation of osseous structures, Magnetic Resonance Imaging (MRI) for precise soft-tissue characterisation, and conventional X-ray radiography. The findings indicate that integrating traditional clinical assessment with radiographic data effectively identifies obstructive factors, such as tonsillar hypertrophy, macroglossia, or airway narrowing associated with obesity. The study concludes that reliance on advanced imaging modalities significantly reduces the incidence of life-threatening events during anaesthesia, thereby enhancing patient safety standards and facilitating the development of precise contingency plans for difficult airway management.

***Keywords*:** Radiologic, Anaesthesia, CT, MRI, X-ray, laryngitis, Hodgkin lymphoma.

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1. Introduction

One of the most important components of effective airway management is orotracheal intubation, which involves choosing the appropriate tools and preparing different approaches to improve patient safety. Developments in medical anaesthetic and surgical procedures, such as airway blockage during procedures, may result in serious side effects like hypoxia, cardiac arrest, or arrhythmias, especially if the patient is completely dependent on anaesthetic assistance to ensure proper ventilation. Fibre-optic evaluation, computed tomography, and ultrasound of clinical evaluation using medical imaging are essential to prevent unanticipated, potentially fatal situations while under anaesthesia (Apfelbaum et al., 2022; Miller et al., 2020; RD, 2009). Preoperative airway assessment is essential for mitigating these risks by allowing medical professionals to determine the possibility of challenging mask ventilation, anomalies, and possible roadblocks using techniques like imaging. The use of imaging techniques has further enhanced the capacity to identify anatomical variations and abnormalities (Apfelbaum et al., 2022). These methods facilitate improved preoperative planning, lessen contemporary airway control, and lower anaesthesia-related issues (Walls & Murphy, 2008).

2. Background and Literature Review

Accurate anatomical assessment is fundamental to the diagnostic work-up and management of head and neck disease. In particular, familiarity with the magnetic resonance imaging (MRI) anatomy of the oral cavity and oropharynx is essential for evaluating lesions caused by neoplastic, infectious, inflammatory, or congenital disorders, because MRI offers excellent soft-tissue contrast and helps determine lesion extent and involvement of adjacent anatomical spaces (Tshering Vogel et al., 2010). In parallel, pre-anaesthetic assessment is evolving through the incorporation of structured clinical evaluation, imaging, digital tools, and risk-prediction approaches. However, the implementation of these emerging methods should remain grounded in the patient’s immediate clinical condition, available resources, and perioperative realities (Viteri Hinojosa, 2024).

Imaging is also important in rhinology and endoscopic sinus surgery. In patients with sinonasal polyps, reduced expression of microRNA-29 has been associated with clinical manifestations such as nasal obstruction and with complete opacification of the anterior ethmoidal sinuses on computed tomography (CT), suggesting a potential relationship between miR-29 expression and disease severity (Ali et al., 2024). In addition, systematic interpretation of preoperative CT images is essential for identifying clinically important anatomical variations and disease extent before endoscopic sinus surgery. The CT checklist developed by Leong et al. helps standardise image interpretation, reduce overlooked findings, and support surgical planning (Leong et al., 2023).

Congenital airway abnormalities require early recognition because infants may present with stridor, abnormal cry, feeding difficulty, respiratory distress, or signs of airway obstruction. In such cases, awake flexible laryngoscopy is generally the first-line evaluation; direct laryngoscopy and bronchoscopy may be required when a more detailed assessment of the larynx, subglottis, trachea, or associated airway lesions is necessary (Varela & Schweiger, 2021). Point-of-care ultrasonography (POCUS) is a rapid, radiation-free adjunct for preoperative airway assessment and airway management. It can assist in predicting difficult intubation through measurements of anterior neck soft-tissue thickness, identify and mark the cricothyroid membrane before emergency front-of-neck access, and provide real-time confirmation of endotracheal-tube placement. However, airway ultrasound complements rather than replaces CT because ultrasound has limited assessment of bony structures and deep anatomical relationships (Lin et al., 2023).

3. General Physical Principles of Medical Imaging

This section discusses the basic physical principles of medical imaging and explains how these principles are applied in some medical imaging techniques.

3. 1. Principles of X-ray Imaging

X-rays are electromagnetic photons with high energy and a brief wavelength. Although they can enter soft tissues, they are heavily absorbed by dense substances like metal or bone. This variation in attenuation permits visualisation of internal structures such as teeth, implants, and bones. High-atomic-number agents, like barium or iodine, are used to see hollow organs and blood vessels. X-rays are produced in a vacuum tube, where electrons emitted from a heated cathode are accelerated toward a tungsten anode under high voltage. When electrons decelerate suddenly at the anode, braking radiation (Bremsstrahlung) is produced (Bushberg et al., 2020).

Characteristic X-rays are generated when inner-shell electrons of the target atom are displaced and replaced by higher-energy electrons. X-ray photons passing through the body may be transmitted, absorbed, or scattered. Absorption and scattering depend on tissue density and atomic number. Bone absorbs more radiation than soft tissue, resulting in brighter regions on radiographs. Scattered photons reduce image contrast and are partially removed using anti-scatter grids (Seeram, 2019; Sprawls, 1995).

3. 2. Computed Tomography (CT)

CT produces cross-sectional images of the body by measuring X-ray attenuation from multiple angles. Unlike conventional radiography, CT eliminates superimposition and provides depth information. A rotating X-ray tube and detector array acquire multiple projections around the patient. Computer algorithms reconstruct these projections into slices with high spatial resolution. Computed Tomography (CT) functions strictly as a diagnostic imaging modality rather than a therapeutic tool in the pre-anaesthetic evaluation of the upper airway. While CT does not deliver direct medical or surgical therapy, its diagnostic utility is critical for proactive intervention and contingency planning. By offering high-contrast, cross-sectional anatomical details, CT allows clinicians to detect subtle bone deformities, structural shifts, and soft-tissue masses that compromise airway space. Consequently, its diagnostic findings guide therapeutic and management decisions, such as modifying the anaesthetic approach, selecting specialised intubation equipment, or initiating surgical interventions (Brown et al., 2014).

3. 3. Magnetic Resonance Imaging (MRI)

MRI is based on the physical properties of protons (hydrogen nuclei) present in the human body, mainly in water and fat. Protons behave like tiny magnets because they possess spin and an associated magnetic moment. When the patient is placed inside a strong external magnetic field, most proton magnetic moments align either parallel or anti-parallel to the field (Al-Khafaji & Sahib, 2024). In the strong magnetic field of the MRI scanner, protons process around the direction of the magnetic field at a frequency known as the Larmor frequency, which is proportional to the magnetic field strength (42.6 MHz per Tesla for hydrogen). A short radiofrequency (RF) pulse is applied to disturb this alignment, tipping the protons away from equilibrium. When the RF pulse is switched off, the protons return to their original alignment while emitting radiofrequency signals that are detected by receiver coils. The return of protons to equilibrium occurs through two independent relaxation mechanisms:

- **T1 relaxation (longitudinal relaxation):** describes the rate at which protons lose excess energy and realign with the main magnetic field.
- **T2 relaxation (transverse relaxation):** describes the rate at which protons lose phase coherence due to local magnetic field differences. MRI images can be weighted based on proton density, T1 relaxation, or T2 relaxation, producing different tissue contrasts. MRI scanners typically operate at magnetic field strengths around 1.5–2 Tesla, which is much stronger than the Earth's magnetic field but not harmful to the human body. The main magnet is usually superconducting

and cooled with liquid helium to maintain 0 electrical resistance. Scan times can be as short as 0.5 seconds per slice, with slice thickness ranging from 0.5 to 2 mm (H Al-khafaji & A.Al-Haidari, 2025).

3. 4. Difference Between Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) in Upper Airway Assessment

Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) are complementary diagnostic tools, each offering distinct imaging capabilities for evaluating the upper airway (Al-Haidari & Al-khafaji, 2024):

a) **Computed Tomography (CT):**

- **Imaging Modality & Physics:** CT utilizes ionizing X-ray radiation to produce high-resolution, cross-sectional anatomical images.
- **Diagnostic Strengths:** CT is exceptional for visualizing osseous (bone) structures, calcifications, and acute airway emergencies.

  Clinical Advantages: CT offers rapid acquisition time (completed in seconds), high spatial resolution, wide accessibility, lower cost, and is ideal for patients who cannot tolerate long scan durations or suffer from acute respiratory distress.
- **Limitations:** Exposure to ionizing radiation and limited soft-tissue contrast compared to MRI.

b) **Magnetic Resonance Imaging (MRI):**

- **Imaging Modality & Physics:** MRI utilises strong magnetic fields and non-ionising radiofrequency pulses.
- **Diagnostic Strengths:** MRI provides superior soft-tissue resolution, making it the gold standard for characterising mucosal lesions, laryngeal/pharyngeal tumours (e.g., Hodgkin lymphoma), and soft-tissue oedema.
- **Clinical Advantages:** MRI offers complete absence of ionising radiation. multi-planar capability with excellent contrast between tumour tissue and adjacent soft tissues.
- **Limitations:** Motion artifact susceptibility, long acquisition times, higher cost, limited availability, and contraindications in patients with metallic implants or severe claustrophobia.

4. Etiology of Perioperative Airway Obstruction

Airway obstruction during surgery can arise from a combination of anatomical, pathological, and anaesthetic-induced factors (H. Al-khafaji et al., 2026).

- **Anatomical and Traumatic Factors:** Skeletal disruptions, such as mandibular or nasal bone fractures, alter upper airway geometry and displace soft tissues posteriorly, thereby compromising airway patency.
- **Pathological and Neoplastic Factors:** Space-occupying lesions—including laryngeal tumours, laryngeal carcinomas, and Hodgkin lymphoma—directly compress or physically occlude the tracheobronchial tree.
- **Inflammatory and Oedematous Factors:** Inflammatory conditions, such as acute laryngitis or severe mucosal oedema, induce airway narrowing and markedly reduce the cross-sectional area of the airway.
- **Anaesthetic-Induced Loss of Muscle Tone:** General anaesthesia and neuromuscular blocking agents suppress upper airway muscle tone, such as the genioglossus muscle, allowing the tongue and soft palate to collapse against the posterior pharyngeal wall.

5. Data Collection and Processing

The clinical cases were obtained from Al-Sader Hospital, Al-Najaf Al-Ashraf Teaching Hospital and National Oncology Hospital with the approval of the Ministry of Health, in accordance with the official letter issued by the Islamic University/Technical College (No. 6799, dated 12/02/2026), which is attached at the end of this research .These cases were analysed using Microsoft Excel to extract statistical data and results. The work was carried out using a Dell computer.

6. Patient and Methods

Table 1. Al-Sader Hospital.

Name	Age	Sex	Weight	Diagnosis	Method Of Examination	Smoker	City
Case1	10	Male	32	Neoplasms of the Nasal Cavity and Larynx	MRI	NO	Najaf
Case2	35	Male	70	Mandibular Fracture	X_Ray	NO	Najaf
Case3	35	Male	70	Mandibular Fracture	CT	NO	Najaf
Case4	25	Male	64	Laryngitis	MRI	NO	Karbala
Case5	65	Male	76	Neoplasms of the Nasal Cavity and Larynx	MRI	NO	Najaf
Case6	18	Female	60	Laryngeal Cancer	MRI	NO	Diwaniya
Case7	26	Male	66	Deviated Septum	CT	Yes	Najaf
Case8	45	Male	82	Laryngeal Cancer	CT	NO	Najaf
Case9	43	Male	86	Laryngeal Cancer	CT	NO	Najaf
Case10	65	Female	90	Deviated Septum	CT	NO	Najaf
Case11	18	Male	70	Nasal Bone Fracture	CT	NO	Najaf
Case12	22	Male	72	Deviated Septum	CT	NO	Najaf
Case13	81	Male	96	Deviated Septum	CT	NO	Najaf
Case14	20	Male	73	Deviated Septum	CT	NO	Najaf
Case15	55	Male	87	Nasal Bone Fracture	CT	Yes	Najaf
Case16	65	Male	92	Deviated Septum	CT	NO	Najaf
Case17	24	Female	58	Deviated Septum	CT	NO	Najaf
Case18	31	Male	82	Neoplasms of the Nasal Cavity and Larynx	CT	Yes	Najaf
Case19	46	Female	71	Deviated Septum	CT	NO	Najaf
Case20	60	Male	88	Deviated Septum	CT	Yes	Najaf
Case21	18	Male	68	Deviated Septum	CT	NO	Najaf

Case22	21	Male	47	Nasal Bone Fracture	CT	NO	Najaf
Case23	35	Male	63	Nasal Bone Fracture	CT	NO	Najaf
Case24	48	Male	92	Laryngitis	CT	Yes	Najaf
Case25	57	Female	76	Nasal Bone Fracture	CT	NO	Najaf
Case26	66	Male	84	Nasal Bone Fracture	CT	Yes	Najaf
Case27	50	Male	84	Laryngeal Tumour	X_Ray	Yes	Diwaniya
Case28	50	Male	84	Laryngeal Tumour	CT	Yes	Diwaniya
Case29	50	Male	79	Laryngeal Cancer	MRI	NO	Najaf
Case30	75	Male	72	Deviated Septum	X_Ray	NO	Najaf
Case31	6	Male	20	Neoplasms of the Nasal Cavity and Larynx	MRI	NO	Bable
Case32	55	Female	73	Laryngitis	CT	NO	Najaf
Case33	55	Female	73	Laryngitis	MRI	NO	Najaf
Case34	15	Male	58	Neoplasms of the Nasal Cavity and Larynx	X_Ray	NO	Najaf
Case35	15	Male	58	Neoplasms of the Nasal Cavity and Larynx	MRI	NO	Najaf

Table 2. National Oncology Hospital.

Name	Age	Sex	Weight	Diagnosis	Method Of Examination	Smoker	City
Case36	90	Male	65	Deviated Septum	MRI	NO	Diwaniya
Case37	40	Female	68	Neoplasms of the Nasal Cavity and Larynx	CT	NO	Najaf
Case38	40	Female	68	Neoplasms of the Nasal Cavity and Larynx	MRI	NO	Najaf
Case39	13	Male	39	Mandibular Fracture	X_Ray	NO	Karbala
Case40	10	Male	35	Neoplasms of the Nasal Cavity and Larynx	CT	NO	Najaf
Case41	65	Male	97	Laryngitis	CT	Yes	Najaf
Case42	57	Male	91	Neoplasms of the Nasal Cavity and Larynx	CT	N0	Diwaniya
Case43	36	Male	72	Hodgkin Lymphoma	CT	Yes	Najaf
Case44	62	Female	88	Laryngeal Tumour	CT	NO	Diwaniya
Case45	85	Male	86	Hodgkin Lymphoma	CT	NO	Najaf
Case46	35	Female	75	Hodgkin Lymphoma	CT	NO	Najaf
Case47	26	Male	76	Laryngitis	CT	Yes	Najaf
Case48	20	Female	69	Hodgkin Lymphoma	CT	NO	Najaf

Case49	47	Male	77	Laryngitis	CT	NO	Najaf
Case50	25	Male	74	Hodgkin Lymphoma	CT	NO	Najaf
Case51	75	Female	87	Laryngitis	CT	NO	Najaf
Case52	60	Female	85	Laryngitis	CT	NO	Najaf
Case53	72	Male	70	Hodgkin Lymphoma	CT	NO	Najaf
Case54	61	Male	86	Hodgkin Lymphoma	CT	NO	Najaf
Case55	73	Female	81	Laryngitis	X-Ray	NO	Najaf
Case56	30	Male	84	Laryngitis	X-Ray	NO	Najaf
Case57	15	Female	53	Hodgkin Lymphoma	CT	NO	Najaf
Case58	60	Male	71	Neoplasms of the Nasal Cavity and Larynx	CT	NO	Babylon
Case59	55	Female	59	Laryngeal Cancer	MRI	NO	Najaf
Case60	72	Male	75	Laryngeal Cancer	CT	NO	Najaf

Table 3. Al-Najaf Teaching Hospital.

Name	Age	Sex	Weight	Diagnosis	Method Of Examination	Smoker	City
Case61	56	Female	63	Deviated Septum	CT	NO	Najaf
Case62	51	Female	81	Laryngitis	X-Ray	NO	Najaf
Case63	66	Female	78	Nasal Bone Fracture	CT	NO	Najaf
Case64	62	Female	73	Laryngeal Cancer	CT	NO	Najaf
Case65	70	Female	73	Laryngeal Cancer	CT	NO	Najaf
Case66	42	Male	82	Hodgkin Lymphoma	CT	Yes	Najaf
Case67	29	Female	65	Laryngitis	CT	NO	Najaf
Case68	55	Male	88	Laryngeal Tumour	CT	Yes	Diwaniya
Case69	31	Female	70	Hodgkin Lymphoma	CT	NO	Najaf
Case70	68	Male	74	Deviated Septum	CT	NO	Najaf
Case71	24	Male	77	Neoplasms of the Nasal Cavity and Larynx	CT	Yes	Diwaniya
Case72	50	Female	81	Laryngeal Cancer	X-RAY	Yes	Najaf
Case73	45	Male	93	Hodgkin Lymphoma	CT	Yes	Najaf
Case74	38	Female	68	Laryngeal Tumour	CT	NO	Najaf
Case75	63	Male	85	Nasal Bone Fracture	CT	Yes	Najaf

Case76	21	Male	72	Deviated Septum	CT	NO	Najaf
Case77	20	Female	75	Hodgkin Lymphoma	MRI	Yes	Najaf
Case78	25	Male	69	Hodgkin Lymphoma	MRI	Yes	Najaf
Case79	72	Female	74	Hodgkin Lymphoma	MRI	Yes	Najaf
Case80	61	Male	70	Hodgkin Lymphoma	MRI	Yes	Najaf
Case81	15	Female	86	Hodgkin Lymphoma	MRI	Yes	Najaf
Case82	42	Male	53	Hodgkin Lymphoma	X-RAY	Yes	Najaf
Case83	31	Female	82	Hodgkin Lymphoma	X-RAY	Yes	Najaf
Case84	45	Male	70	Hodgkin Lymphoma	X-RAY	Yes	Najaf
Case85	50	Male	55	Laryngeal Tumour	X_Ray	NO	Najaf
Case86	50	Male	50	Laryngeal Tumour	X_Ray	NO	Najaf
Case87	62	Female	52	Laryngeal Tumour	X_Ray	Yes	Najaf
Case88	55	Male	53	Laryngeal Tumour	MRI	Yes	Najaf
Case89	38	Female	56	Laryngeal Tumour	MRI	Yes	Najaf
Case90	55	Male	55	Laryngeal Tumour	MRI	Yes	Najaf
Case91	38	Female	54	Laryngeal Tumour	MRI	Yes	Najaf
Case92	75	Female	87	Laryngitis	MRI	Yes	Najaf
Case93	60	Female	85	Laryngitis	MRI	Yes	Najaf
Case94	73	Female	81	Laryngitis	MRI	Yes	Najaf
Case95	30	Male	84	Laryngitis	MRI	Yes	Najaf
Case96	51	Female	81	Laryngitis	MRI	Yes	Najaf
Case97	57	Female	47	Nasal Bone Fracture	X-RAY	NO	Najaf
Case98	66	Male	63	Nasal Bone Fracture	X-RAY	NO	Najaf
Case99	66	Female	76	Nasal Bone Fracture	X-RAY	NO	Najaf
Case100	63	Male	84	Nasal Bone Fracture	X-RAY	NO	Najaf
Case101	66	Female	78	Nasal Bone Fracture	X-RAY	NO	Najaf
Case102	63	Male	85	Nasal Bone Fracture	X-RAY	NO	Najaf
Case103	45	Male	60	Mandibular Fracture	X-Ray	NO	Najaf

Case104	45	Male	60	Mandibular Fracture	X-Ray	NO	Najaf
Case105	45	Male	60	Mandibular Fracture	X-Ray	NO	Najaf
Case106	46	Male	66	Mandibular Fracture	CT	NO	Najaf
Case107	49	Male	66	Mandibular Fracture	CT	NO	Najaf
Case108	50	Male	66	Mandibular Fracture	CT	NO	Najaf
Case109	51	Male	77	Mandibular Fracture	X-Ray	NO	Najaf

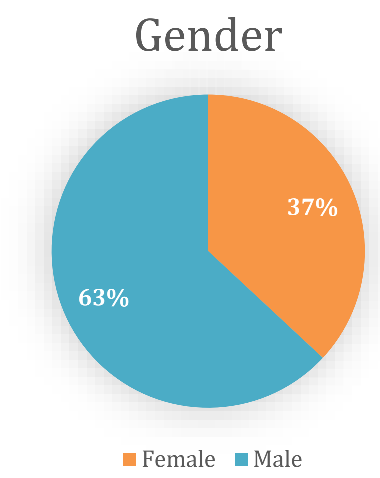

Figure 1. Percentage (%) of gender female and male.

Demographic analysis of the study sample revealed a higher prevalence and severity of upper airway pathologies among male patients (63%) compared to female patients (37%), as illustrated in **Figure 1.**

This gender variation can be attributed to several biomechanical, behavioural, and occupational factors:

1. **Trauma and Facial Fractures:** Male individuals generally exhibit higher exposure rates to high-energy facial trauma, road traffic accidents, and occupational hazards, leading to a higher incidence of complex nasal bone and mandibular fractures.
2. **Neoplastic Risk Factors:** High-risk behaviours, particularly chronic tobacco smoking and alcohol consumption, are statistically more prevalent among males in the studied demographic and directly contribute to an increased risk of laryngeal carcinoma and upper airway malignancies.
3. **Anatomical and Tissue Differences:** Males typically possess larger laryngeal dimensions and higher soft-tissue volume in the upper airway, which can lead to more pronounced airway narrowing and collapse under the influence of general anaesthetic agents.

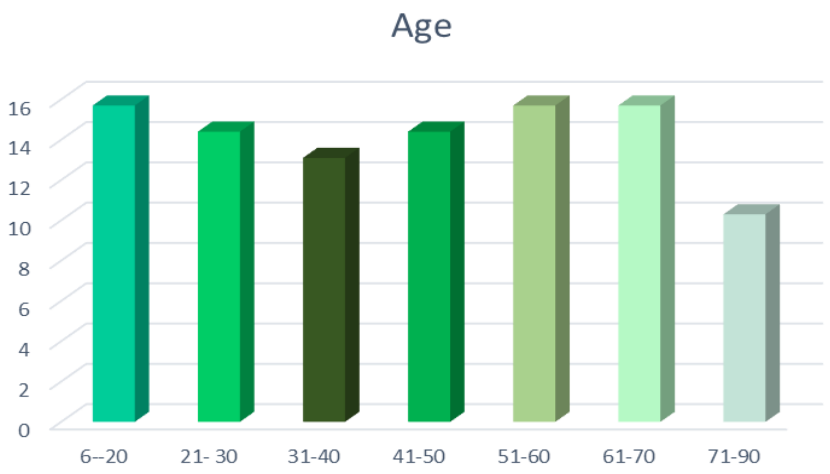

Figure 2. The mean of age among age groups.

This graph shows that the age groups between 6-20 and 50-90 are the most frequent visitors to hospitals.

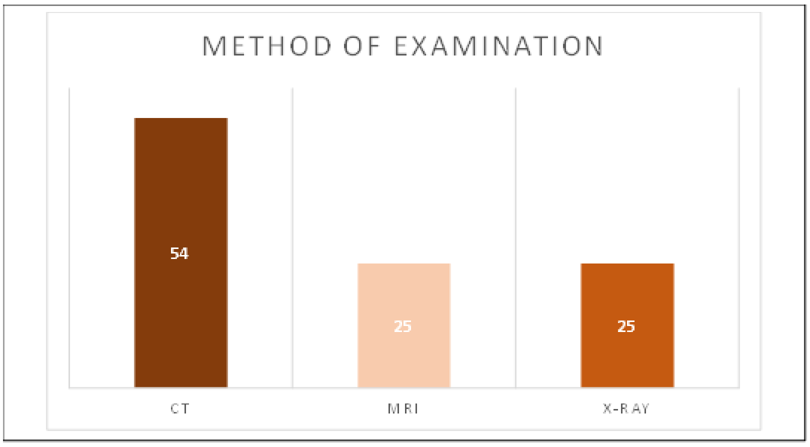

Figure 3. Method of examination.

This diagram shows us that most cases are examined using CT scans, and we attribute this to its accuracy, availability, speed of examination, and low cost.

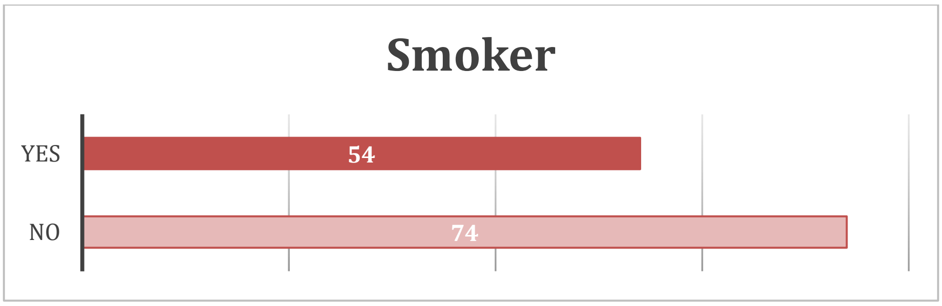

Figure 4. Percentage (%) of smokers.

This graph shows that the percentage of non-smoking patients is higher than the percentage of smoking patients.

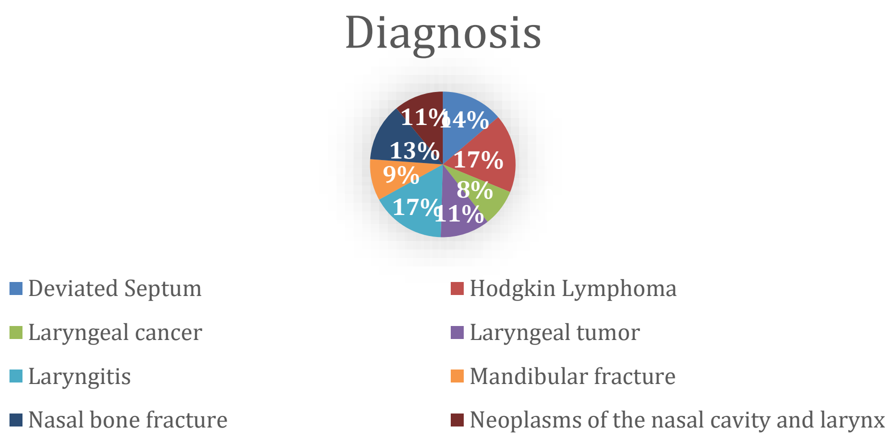

Figure 5. Percentage (%) of total number of disease cases.

This graph shows the percentage of diagnosed cases out of the total number of disease cases.

7. Results

Table 4. Shows the Cases Examined by X-ray.

Type of Condition	Total Number of Cases	Cases Detected by X-ray	Detection Rate (%)	Number of Cases in Which the Anaesthetic Plan Was Modified
Deviated Septum	16	1	6.25 %	1
Hodgkin Lymphoma	20	3	15 %	0
Laryngeal cancer	10	1	10 %	0
Laryngeal tumour	12	4	33.3 %	0
Laryngitis	18	3	16.7 %	0
Mandibular fracture	10	6	60 %	5
Nasal bone fracture	14	6	42.9 %	5
Neoplasms of the nasal cavity and larynx	12	1	8.3%	0

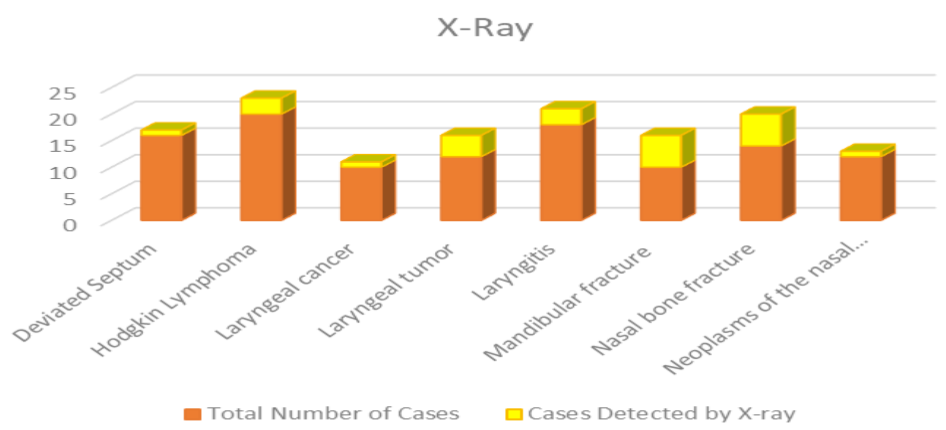

Figure 6. Cases Detected by X-Ray

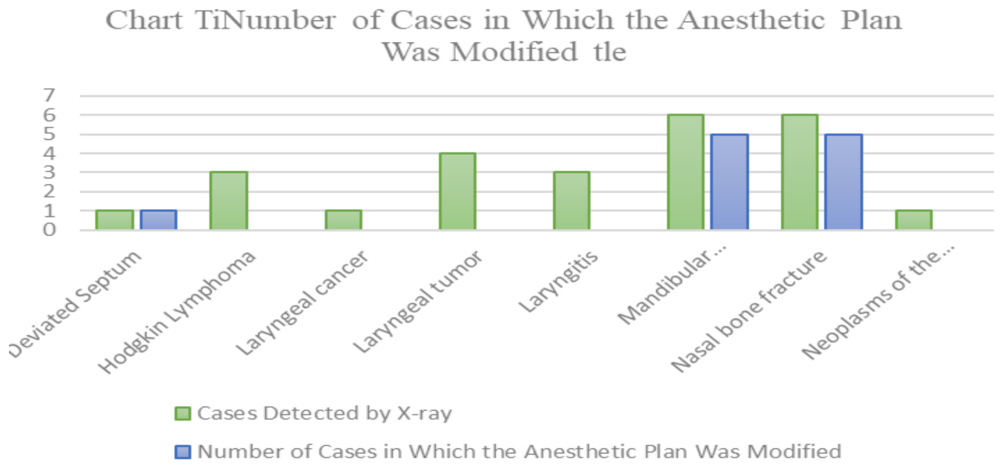

Figure 7. Number of Cases in Which the Anaesthetic Plan Was Modified by X-Ray.

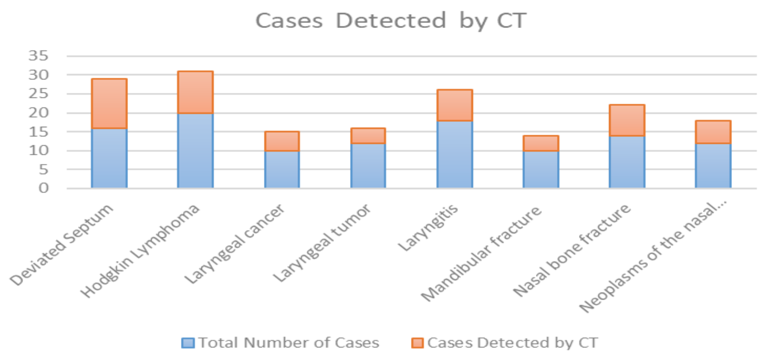

Figure 8. Cases Detected by CT.

Table 5. Shows the Cases Examined by CT.

Type of Condition	Total Number of Cases	Cases Detected by CT	Detection Rate (%)	N. Cases the Anaesthetic Plan Was Modified
Deviated Septum	16	13	81.25 **%**	10
Hodgkin Lymphoma	20	11	55 **%**	3
Laryngeal cancer	10	5	50 **%**	5
Laryngeal tumour	12	4	33.3 **%**	5
Laryngitis	18	8	44 **%**	8
Mandibular fracture	10	4	40 **%**	3
Nasal bone fracture	14	8	57.14 **%**	8
Neoplasms of the nasal cavity and larynx	12	6	50 **%**	5

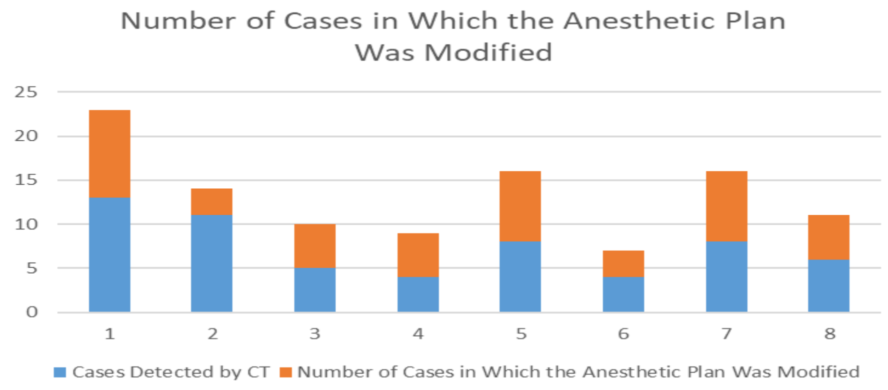

Figure 9. Number of Cases in Which the Anaesthetic Plan Was Modified CT.

The variance in the percentages of anaesthetic plan modifications depicted in **Figure 9** reflects the distinct anatomical and pathological impacts of each condition on upper airway patency:

1. **High-Modification Pathologies:** Conditions presenting with severe anatomical narrowing, structural rigidity, or tissue mass such as laryngeal carcinomas, severe nasal septum deviations, and acute jaw/facial fractures demonstrated the highest modification rates (reaching up to 100%). These pathologies pose a direct threat of acute airway collapse during anaesthetic induction, necessitating proactive adjustments such as video laryngoscopy, awake fibreoptic intubation, or surgical tracheostomy preparation.
2. **Moderate- to Low-Modification Pathologies:** Conditions characterised by minor localised inflammation or non-obstructive tissue shifts required less frequent alterations to standard intubation protocols, as they posed a lower risk of complete airway occlusion.

Consequently, the degree of anaesthetic modification correlates directly with the structural severity and location of the lesion identified via CT imaging.

Table 6. Shows the Cases Examined by MRI.

Type of Condition	Total Number of Cases	Cases Detected by MRI	Detection Rate (%)	N. of Cases in Which the Anaesthetic Plan Was Modified
Deviated Septum	16	1	6.25	1
Hodgkin Lymphoma	20	5	25	4
Laryngeal cancer	10	3	30	1
Laryngeal tumour	12	4	33.3	1
Laryngitis	18	7	38.8	3
Mandibular fracture	10	4	40	3
Nasal bone fracture	14	0	0	0
Neoplasms of the nasal cavity and larynx	12	5	41.6	4

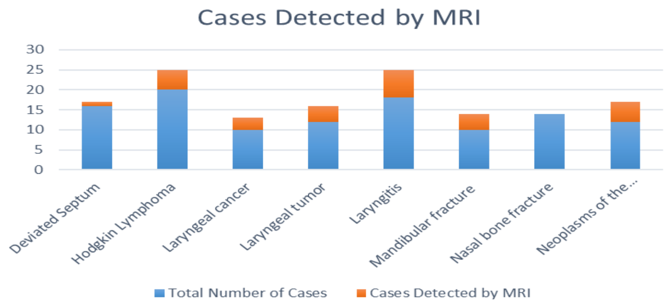

Figure 10. Cases Detected by MRI.

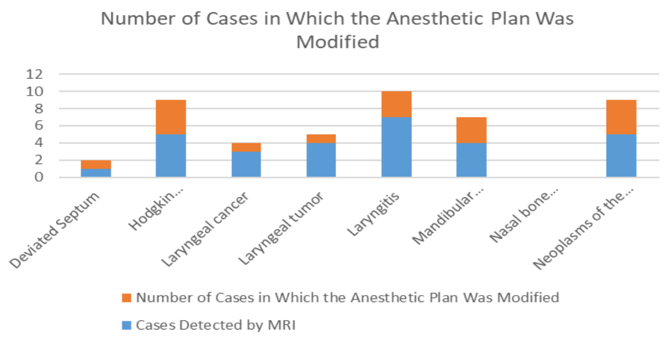

Figure 11. Number of Cases in Which the Anaesthetic Plan Was Modified by MRI.

Table 7. Shows Cases (Difficulty Airway) of Total Condition by X-RAY, CT, and MRI.

Imaging Modality	Total Cases Examined	Difficult Airway Diagnosed
X-ray (Plain Radiography)	25	11
CT scan (Computed Tomography)	59	47
MRI (Magnetic Resonance Imaging)	29	17

Although Magnetic Resonance Imaging (MRI) does not emit ionising radiation, Computed Tomography (CT) was utilised in the majority of clinical cases in this study (as shown in Figure 3). This clinical preference is justified by several critical factors in pre-anaesthetic airway evaluation:

- ✓ **Rapid Acquisition Time:** CT scans are completed within seconds, whereas MRI sequences require 20 to 45 minutes. For patients with compromised airways or acute dyspnoea, maintaining a supine position for extended periods during MRI poses a severe risk of acute asphyxiation.
- ✓ **Bony and Structural Detail:** CT provides superior spatial resolution for evaluating complex facial/nasal fractures and calcified laryngeal structures, which are essential for structural airway mapping.
- ✓ **Availability and Cost-Effectiveness:** CT scanners are widely available in emergency departments and teaching hospitals, with lower procedural costs and faster throughput compared to MRI.
- ✓ **Motion Artifact Reduction:** Because CT scanning is ultra-fast, it minimises motion artifacts caused by patient breathing, coughing, or distress, thereby ensuring reliable diagnostic images.

Consequently, the immediate diagnostic clarity and safety provided by CT during pre-anaesthetic planning outweigh the theoretical risks associated with ionising radiation in acute clinical settings.

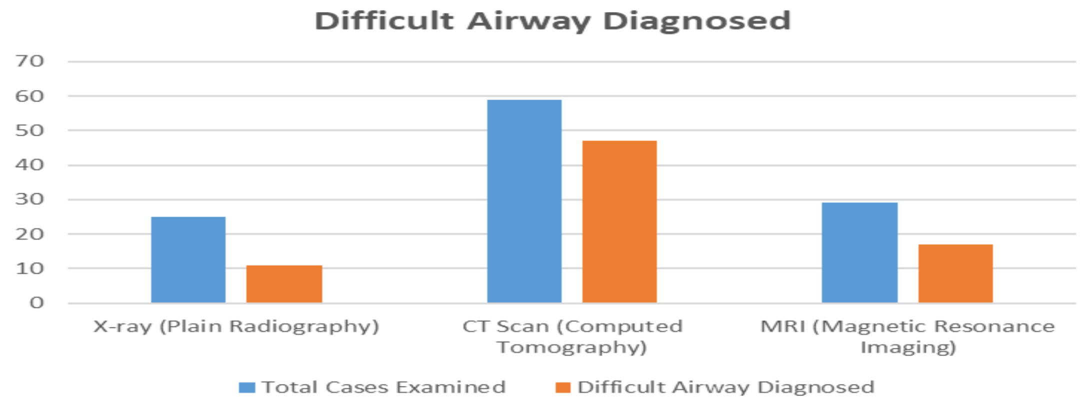

Figure 12. Difficult Airway Diagnosed.

8. Impact of Preoperative Imaging on Anaesthetic Management

Radiologic evaluation plays a pivotal role in modifying and tailoring anaesthetic strategy prior to surgery. By providing detailed anatomical maps of the upper airway, pre-anaesthetic medical imaging enables anaesthesiologists to identify potential airway compromise—such as subglottic stenosis, tracheal deviation, or laryngeal tissue mass—that may not be evident during routine bedside clinical exams (e.g., Mallampati scoring).

Consequentially, these radiological findings directly influence anaesthetic management by:

- **Determining Intubation Strategy:** Guiding the decision between standard direct laryngoscopy and advanced techniques (e.g., video laryngoscopy, fibreoptic intubation, or awake intubation).
- **Selecting Airway Equipment:** Assisting in the precise sizing of endotracheal tubes to minimise mucosal trauma or airway resistance.
- **Emergency Preparedness:** Allowing the surgical and anaesthetic team to prepare for a "cannot intubate, cannot oxygenate" (CICO) scenario by having emergency surgical airway equipment (e.g., cricothyroidotomy kits) readily available.
- **Procedural Safety:** Notably, no catastrophic airway events, surgical airway emergencies, or complete intubation failures were recorded among patients evaluated with pre-anaesthetic imaging, reinforcing its critical role in clinical risk reduction.

9. Correlation of Pathological Diagnoses with Difficult Airway Mechanics

Although this investigation evaluated the diagnostic performance of cross-sectional imaging across specific clinical pathologies (e.g., maxillofacial fractures, soft-tissue masses, mucosal oedema, and tracheal deviation), these structural lesions serve as the primary pathological determinants of difficult airway management. Rather than relying exclusively on geometric or metric measurements, such as retropharyngeal space thickness or mandibular angle degree, the volumetric and morphological alterations delineated on CT and MRI—including luminal narrowing, anatomical displacement, and tissue rigidity—directly predict the physical difficulty encountered during laryngoscopy. Consequently, establishing a precise radiological diagnosis directly connects pre-procedural imaging findings with clinical airway difficulty scoring and proactive risk mitigation (Li et al., 2022).

10. Conclusion

- Study Limitations: A key limitation of this investigation is the relatively modest sample size (n = 109), which was gathered via convenience sampling across three major clinical centres. While this multi-centre approach enhances the representativeness of the findings, the study was designed as a descriptive pilot investigation focused on observing clinical imaging patterns and anaesthetic plan modifications, rather than establishing formal diagnostic test accuracy metrics, such as sensitivity, specificity, or predictive values. Consequently, subgroup observations across specific pathological categories should be interpreted as exploratory, warranting larger prospective trials to provide further statistical validation.
- **Table 4** presents the distribution of medical conditions examined using X-ray imaging, including the total number of cases for each condition, the number of cases detected by X-ray, the detection rate, and the impact of X-ray findings on modifications to the anaesthetic plan. The findings indicate that the effectiveness of X-ray imaging varies depending on the type of condition. It showed low diagnostic efficiency in certain conditions, such as deviated septum, where only 1 out of 16 cases was detected (6.25%), as well as in neoplasms of the nasal cavity and larynx, with a detection rate of 8.3%. Similarly, detection rates were low to moderate in conditions such as Hodgkin lymphoma (15%), laryngeal cancer (10%), and laryngitis (16.7%), while relatively better detection was observed in laryngeal tumors, reaching 33.3%.
- In contrast, X-ray imaging demonstrated high effectiveness in diagnosing bony injuries. The highest detection rate was observed in mandibular fractures (60%), followed by nasal bone fractures (42.9%), indicating that X-ray is a reliable diagnostic tool for such conditions. Regarding the impact on the anaesthetic plan, modifications were minimal in most cases, except in fracture-related conditions. The anaesthetic plan was modified in 5 cases of mandibular fractures and 5 cases of nasal bone fractures, as well as in one case of deviated septum. This highlights the clinical importance of X-ray findings in guiding anaesthetic decisions, particularly in cases involving bony injuries. Overall, it can be concluded that X-ray imaging has high diagnostic value in detecting fractures, while its effectiveness is limited in diagnosing tumours and inflammatory conditions, thus necessitating the use of additional diagnostic modalities in such cases, as in **Figures 6** and **7**.
- **Table 5** presents the results of using computed tomography (CT) in the diagnosis of various medical conditions, highlighting its detection efficiency as well as its impact on modifying the anaesthetic plan. It displays the total number of cases for each condition, the number of CT-detected cases, and the matching rate of detection. The results show that CT demonstrated the greatest diagnostic precision in deviated septum cases, with a detection rate of 81.25%, as 13 of the 16 cases were found. Meanwhile, a number of laryngeal cancers and neoplasms of the nasal cavity and larynx had detection rates of about 50%, whereas conditions like nasal bone fractures (57.14%) and Hodgkin lymphoma (55%) had moderate detection rates. Lower detection rates were observed in laryngeal tumours (33.3%), mandibular fractures (40%), and laryngitis (44%), suggesting limited sensitivity of CT in these conditions.
- Furthermore, the table highlights the important role of CT in influencing anaesthetic management. A considerable number of cases required modification of the anaesthetic plan based on CT findings, particularly in patients with a deviated septum (10 cases) and those with laryngitis and nasal bone fractures (8 cases each). On the other hand, CT had a lesser impact on anaesthetic decisions in conditions such as Hodgkin lymphoma and mandibular fractures, where only 3 cases required modification. Overall, CT can be considered a valuable diagnostic tool; however, its effectiveness varies depending on the type of condition. Additionally, it plays a significant role in improving anaesthetic decision-making, thereby enhancing patient safety during medical procedures, as illustrated in **Figures 8** and **9**.
- **Table 6** presents the results of using MRI in diagnosing a variety of medical conditions, as well as its impact on modifying the anaesthetic plan. The findings show that the effectiveness of MRI varies depending on the type of condition. In cases of a deviated septum, MRI had a very limited role, detecting only 1 out of 16 cases, which represents

a low detection rate. In contrast, for Hodgkin lymphoma, MRI demonstrated a relatively better performance, identifying 5 out of 20 cases, and contributing to changes in the anaesthetic plan in several instances.

- Regarding laryngeal conditions, such as laryngeal cancer and laryngeal tumours, MRI showed moderate effectiveness, with detection rates ranging from 30% to 33.3%. Its performance was slightly higher in cases of laryngitis, where the detection rate reached approximately 38.8%.
- For fracture-related conditions, MRI proved useful in detecting mandibular fractures, with a detection rate of 40%. However, it showed no effectiveness in nasal bone fractures, as no cases were detected.
- The highest detection rate was observed in neoplasms of the nasal cavity and arynx, reaching 41.6%. These cases also had a notable impact on modifying the anaesthetic plan.
- Overall, MRI appears to be more effective in diagnosing tumours and inflammatory conditions than simple fractures, and it plays an important role in guiding clinicians to adjust anaesthetic plans according to the patient's condition , as shown in **Figures 10** and **11.**
- **Table 7** presents the number of cases examined using three different imaging modalities X-ray (plain radiography), CT (computed tomography), and MRI (magnetic resonance imaging) along with the number of cases diagnosed as "difficult airway" by each method.
- Overall, it can be observed that the highest number of examined cases was with CT, totalling 59 cases, followed by MRI with 29 cases and X-ray with 25 cases. In terms of diagnosed difficult airway cases, CT also recorded the highest number at 47 cases, indicating a greater ability to detect this condition compared to the other modalities.
- In contrast, X-rays diagnosed only 11 cases out of 25, which is relatively low and may reflect limited sensitivity in detecting difficult airways. MRI diagnosed 17 cases out of 29, showing a moderate performance between CT and X-ray.
- Additionally, CT is more commonly used in emergency situations and urgent procedures than MRI because CT scans are faster and provide results in a short time, which is critical in life-threatening or time-sensitive conditions. In comparison, MRI is relatively slower and requires more time to complete, making it less suitable for emergency use. Overall, CT appears to be the most effective imaging modality for diagnosing a difficult airway, particularly in emergency settings, followed by MRI, while X-ray ranks last in terms of diagnostic capability, as in **Figure 12.**

Conflict of Interest

The authors declare that there is no conflict of interest or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

All necessary data generated or analyzed during this study are included in this article. Any additional data could be available from the corresponding author upon request.

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