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Comprehensive Clinical Anesthesia

Look Inside the Book



Editors

Atul P Kulkarni

Vandana Agarwal

Vijaya P Patil

Jigeeshu V Divatia

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CHAPTER

16

Role of Ultrasound in Anesthesia

Shilpushp Bhosale, Atul P Kulkarni

HIGHLIGHTS

- Ultrasound use in anesthesia has increased tremendously and virtually replaced the stethoscope in practice.
- Appropriate image acquisition and optimization with interpretation of artifacts remains key in perioperative diagnostics.
- Enormous progress has happened in ultrasound for regional anesthesia and allowed the possibility of various newer blocks and plane blocks.
- Various protocols such as the BLUE protocol and FALLS protocol have revolutionized application of lung ultrasound.
- Transthoracic and transesophageal echocardiography remain the cornerstone in diagnosis of shock states along with hemodynamic monitoring.
- Newer applications of ultrasound such as airway ultrasound, transcranial Doppler and optic nerve sheath diameter have taken ultrasound application in anesthesia to newer heights.

INTRODUCTION

Ultrasound imaging is safe and rapidly evolving imaging modality, with constantly improving software to provide better resolution and enhanced tissue penetration. There are expanding applications for this technology in anesthesia such as regional anesthesia and chronic pain blocks, airway assessment, vascular access, transthoracic and transesophageal echocardiography, along with emerging applications such as lung ultrasound, neuromonitoring, etc.

PHYSICS OF ULTRASOUND

When sound waves are sent into body, they are reflected at the interfaces between tissue and the return time of the waves or echoes tells us the depth and character of the reflecting surface.

Human sensitivity for sound waves is between 20 and 20,000 Hz range whereas Medical Ultrasound uses frequencies which are way above (typically from 2 to 15 MHz) this range. Ultrasound waves are created by piezoelectric crystals housed in the probe (Piezoelectric effect). When an alternating current is applied crystals change shape and vibrate at a particular frequency and the electrical energy is converted into acoustic energy. The sound wave propagates by longitudinal motion, i.e., by compression and expansion into the tissues. The returned waves produce echoes, which are finally converted into electrical signals **(Fig. 1)**. The wave characteristic is described in terms of amplitude, wavelength, frequency, and velocity **(Fig. 2)**. The time taken for each echo to return back to the transducer is proportional to distance traveled. The crystal receives the sound waves reflected back from the tissues and creates images in gray scale based on the time and the strength of the returned echoes, i.e., it acts like a speaker and microphone. Air and bone absorb most of the beam, while sound travels at different speeds through tissues, blood,

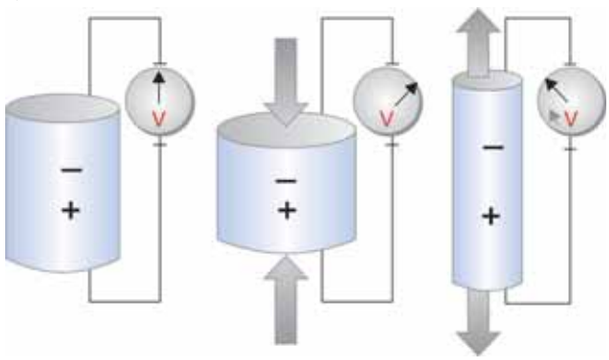

Fig. 1: Piezoelectric effect.

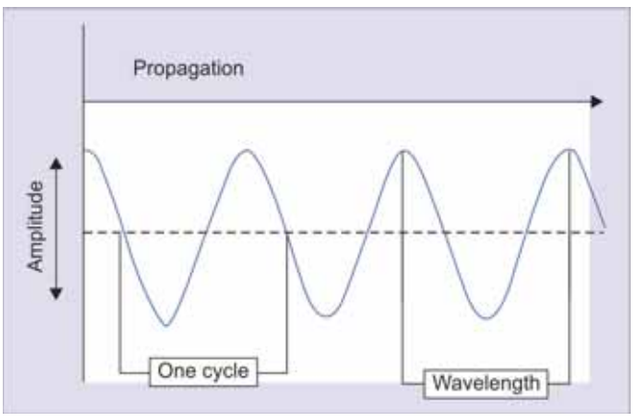

Fig. 2: Ultrasound wave characteristics.

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fluid, etc., i.e., propagation velocity is determined by acoustic impedance. Fluids or blood create less echo (hypoechoic) and appear black on screen, while more reflective tissues that allows less beam to pass (e.g., fat and bone) create stronger echoes (hyperechoic) and appear white on the screen.

The frequency of the transducer depends on crystal thickness thus determining the depth and resolution of the transducer. The higher frequency probes (linear probes 7–13 MHz) have lower penetration but good resolution hence are better for superficial structures, while low frequency probes have good penetration and are better for deeper structures but lack resolution (curved, phased array probes 2–5 MHz).

MODES OF IMAGING

B (Brightness) or 2D Mode

It is most commonly used mode where brightness depends on the intensity of the echo received from the corresponding location in the body. This mode is used to evaluate and scan organs in real time.

M (Motion) Mode

This mode displays the motion of structures along a single line (i.e., axis of the ultrasound beam) over time and illustrates changes in 2D ultrasound appearance with movement. M-mode is used for evaluation of valve motion, variability of vena cava, lung sliding, or diaphragmatic movement.

Doppler modes detect frequency shifts created by change in sound reflections of a moving structures, i.e., blood flow (Doppler effect) or moving tissues by tissue Doppler. The color Doppler uses color to represent the speed and direction of blood flow through the vessel. The colors (red is flow toward transducer and blue is flow away from transducer) denote flow direction regardless of the nature of vessel, i.e., vein or artery. Pulsed wave Doppler transmits short pulses of ultrasound and waits for Doppler signals. It allows measurements of blood velocity from a small region accurately. Continuous wave Doppler (CWD) on the other hand, transmits and receives continuous ultrasound waves. Thus, signals are obtained as overlap of the transmitted and received ultrasound beams. It is useful for measuring high velocities but have a poor ability to localize a flow signal accurately.

ULTRASOUND-GUIDED PROCEDURES

Ultrasound has gained widespread applications in anesthesiology leading to significant improvement in safety of procedures as compared to anatomical methods. Real-time ultrasound is superior as the needle advancement is continuously seen.

The two approaches of needle placement are the short-axis view (i.e., out of plane approach), where the needle is only seen as an echogenic dot on screen (but may not necessarily be the tip of the needle), while the long-axis view (in-plane approach), where the entire needle traversing can be seen thus reducing the risk of inadvertent puncture of other structures **(Fig. 3)**.

Advances in technology, software and also in needles (such as coating, scoring with multifaceted tips, and needle guides designed to increase their ultrasound reflectivity), have significantly improved the ease of procedures.

ULTRASOUND VASCULAR ACCESS

The clinical use of ultrasound in anesthesia began with vascular access to increase the safety and quality of central venous catheter (CVC) placement and reduce the complications.

It is widely accepted that traditional landmark techniques for central venous cannulation can be challenging and dangerous in certain patients like pediatric, patients, patients with anatomic variations, venous thrombosis, coagulopathy, obesity, or patients in shock. Repeated attempts can also increase the chances of complications. Ultrasound helps to identify vessel position, its patency, and any anatomical variations. It also helps in rapid detection of any procedural complications such as bleeding, pneumothorax, etc.

Studies have shown significant reduction in complication rates with ultrasound CVC placements with rates of 4% compared to 13.5% using landmark technique.

The American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists strongly recommend the use of real-time ultrasound for CVC placement in the internal jugular vein (IJV) (1A).

A linear or hockey stick probe with high frequency and better resolution for superficial structures (7–13 Hz) is used for vascular access.

ULTRASOUND FOR REGIONAL ANESTHESIA

With emphasis on increased efficacy, accuracy, and safety of regional anesthesia, ultrasound has now become the gold standard for regional anesthesia.

Ultrasound by increasing the success and duration of block improves postoperative pain significantly thus reducing the patient's exposure to narcotics. It undoubtedly improves length of stay, delirium incidence, overall patient satisfaction, and functional recovery. With ultrasound correct placement and spread of anesthetic around the nerve results in faster onset, improves quality and duration of block. It decreases the volume of injection, lowering the risk for local anesthesia toxicity. Ultrasound can also show the dangerous needle and nerve relationship such as direct nerve stimulation or high injection pressure if needle tip is within epineurium.

Ultrasound helps block smaller nerves or those in difficult anatomic locations with a significantly higher success rates compared to nerve stimulation. Ultrasound also has enabled clinicians to easily perform blocks such as brachial or lumbar plexus, sciaticofemoral blocks, thoracic paravertebral catheter

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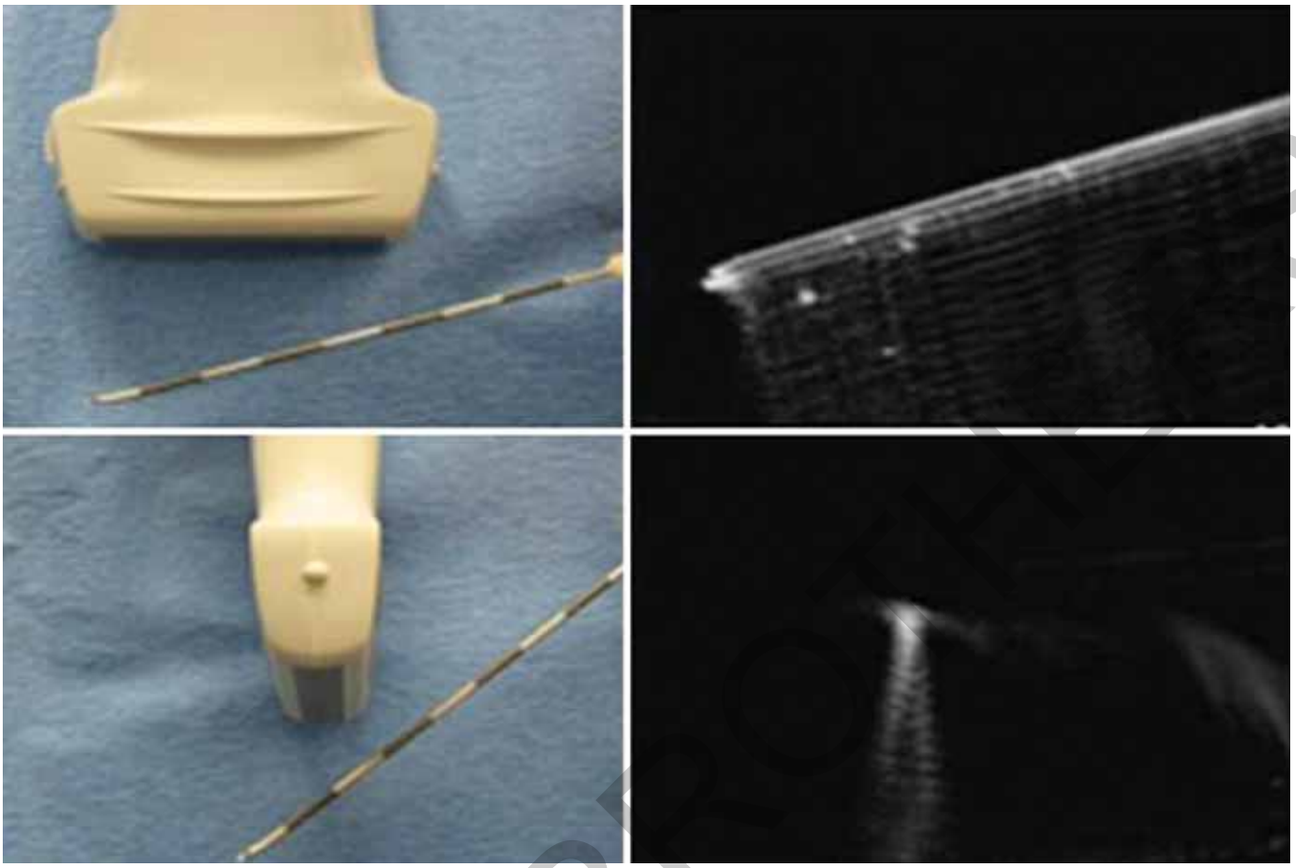

Fig. 3: In plane/out of plane approach.

placement, etc., which were initially considered difficult. Fascial plane blocks, such as rectus sheath or ilioinguinal, transversus abdominis (TAP), that cannot be performed without ultrasound, are now commonly performed.

For epidural or spinal spaces which are encased in bones where ultrasound will not pass, can be done using acoustic windows such as the interspinous space and intralaminar space.

Ultrasound has become a commonly used modality in performance of chronic pain interventions and has started to replace CT scans and fluoroscopy in procedures such as nerve root blocks, stellate ganglion block, transforaminal injections for radicular pain, facet joint block, intra-articular joint injections.

AIRWAY ASSESSMENT

Applications of airway ultrasound have gathered momentum recently. Ultrasound has been used for airway-related nerve blocks, along with emergency airway procedures and assessment of airway anatomy. Airway ultrasound can be performed by submental and anterior neck approach in both sagittal and coronal plane. The submental view is best obtained with curvilinear probe, which offers ease of application whereas the linear high-frequency probe is best for anterior neck approach.



Fig. 4: String of pearls sign.

When we place the linear probe in longitudinal plane, the cricoid cartilage can be seen as a hypoechoic hump while the thyroid cartilage and thyroid rings are seen as a "string of beads" **(Fig. 4)**. The mucosa just beneath these structures is identified as hyperechoic line formed by reverberation artifacts from air-mucosal interface.

The false and true vocal cords can also be seen using transverse plane through the thyroid cartilage window to identify vocal cord abnormalities.

Studies have shown ultrasound to be superior to age-based endotracheal tube size selection. There is good correlation

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between subglottic transverse diameter and the outer diameter of endotracheal tube (ETT).

The ultrasound measurement of tracheal width can be used to select the double-lumen tube size as well.

Ultrasound is used for prediction of difficult airway, and real-time confirmation of endotracheal tube placement by the loss of "snow storm sign," or esophageal intubation by the "double barrel sign" **(Figs. 5A and B)**.

Diagnosis of epiglottitis can also be made with ultrasound, when epiglottis thickness cutoff of 2.4 mm is exceeded.

Ultrasound can help identify cricothyroid membrane since in complete ventilation failure situation, the landmark technique for identifying cricothyroid membrane is not easy for performing cricothyroidotomy. Ultrasound has also been shown to be useful in assisting placement of Ryles tubes or difficult tracheostomies.

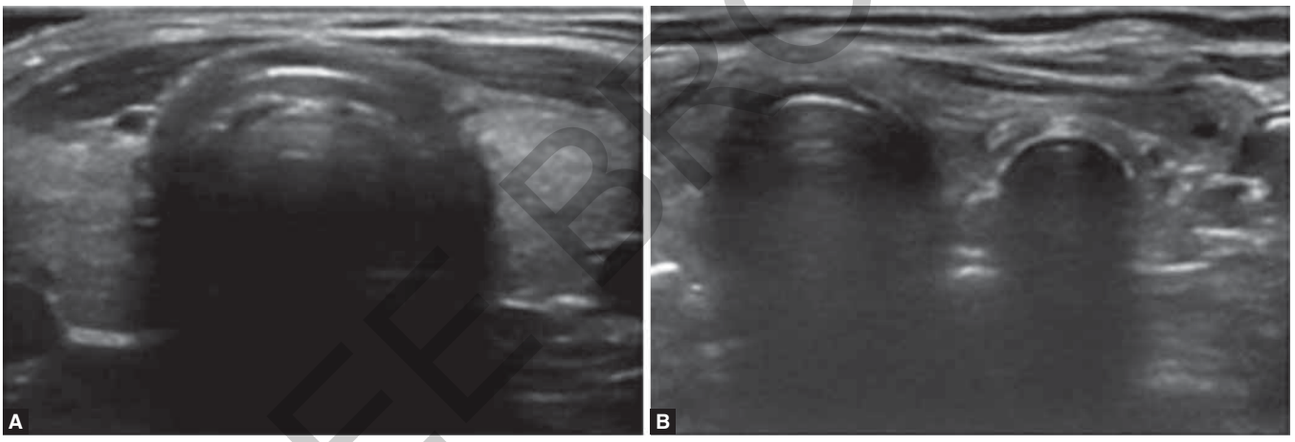
Ultrasound measurement of air column width at the level of the vocal cords represents the amount of air passing around the tube and through the vocal cords. This can be used to predict likelihood of postextubation stridor, denoting presence of laryngeal edema.

LUNG ULTRASOUND

Lung ultrasound is extensively used for rapid diagnosis of causes of hypoxia and shock such as pneumothorax, pulmonary edema, pulmonary embolism, consolidation, pneumonia, atelectasis, pleural effusion, etc.

The pleural line is highly reflective and causes multiple reverberation artifacts, which are equally spaced, and go side to side (A-lines) these are separated from each other by the shadow of the ribs (bat wing sign) **(Figs. 6A and B)**.

In normally ventilated lungs, parietal and visceral pleurae slide over each other, which is seen as a shimmering movement, this is called lung sliding sign. The small vertical lines moving down from the pleura are the Z-lines (which do not reach the edge of the screen) whereas long vertical lines from pleura to the end of screen are due to the presence



Figs. 5A and B: (A) Loss of snow storm sign; (B) Double barrel sign.

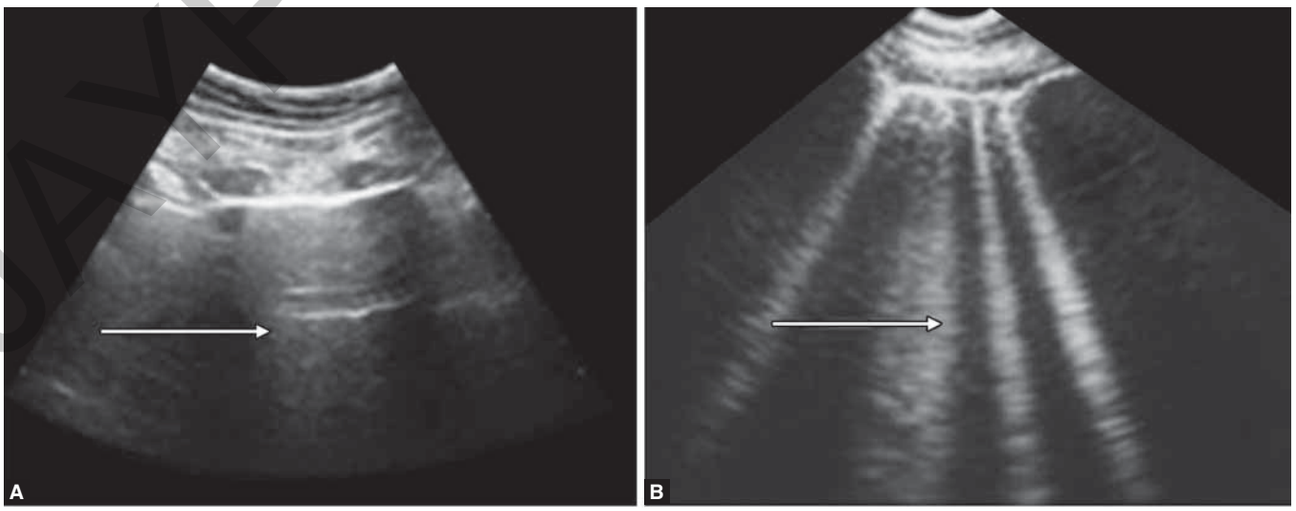


Fig. 6A and B: Lung ultrasound (A line and B line).

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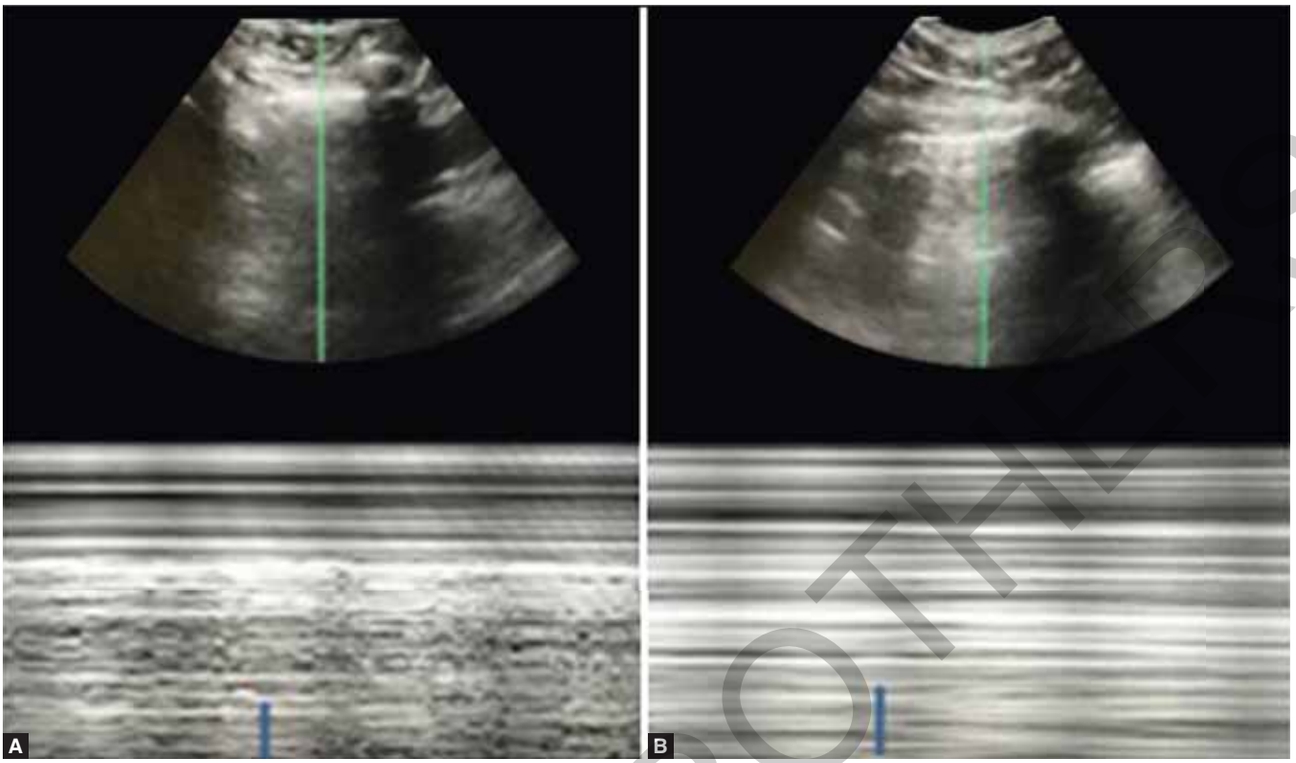

Figs. 7A and B: (A) Seashore sign; (B) Stratosphere sign on M-mode.

of fluid in the interstitial space (B-lines). If the B-lines are present, then the A-lines disappear.

The M-mode at pleural line gives characteristic gray pixelated appearance of lung sliding, which looks similar to sand on a beach and this is termed as seashore sign. Identification of lung sliding excludes the presence of pneumothorax. Loss of lung sliding caused by presence of air between the two pleura obscures ultrasound penetration of underlying structure. On M-mode, this is seen as a classical stratosphere sign (or bar code sign) **(Figs. 7A and B)**.

The presence of B-lines or Z-lines excludes presence of pneumothorax as these signs rely on opposition of the two layers of pleura. Since loss of lung sliding may be caused by any condition that prevents movement of the pleura, lung ultrasound is better at ruling out pneumothorax rather than ruling it in. However, 100% specific feature of pneumothorax is identification of a lung point, i.e., point where lung sliding abuts area of no lung sliding, which is the contact point, where the pneumothorax ends and the two layers of pleura contact each other and lung sliding is seen again.

Pneumothorax can also be ruled out when lack of lung sliding is due to absent ventilation but has characteristic lung pulse created by transmitted cardiac oscillations, this is seen as T-shaped gray pixelated pattern on M-mode.

Ultrasound also detects characteristic patterns of consolidation due to air trapped with fluid-filled lung. This is called Shred sign. The consolidation may be accompanied by effusion which is commonly seen caudally and posteriorly (PLAPS: Postero-Lateral Alveolar and/or Pleural Syndrome point).

Lung ultrasound appearance of multiple B-lines can be seen in various conditions such as pulmonary edema, pneumonia, and acute respiratory distress syndrome. These are collectively called as alveolar interstitial syndrome.

Pulmonary edema is characteristic where dense multiple B-lines are typically separated by a distance <3 mm. This feature is clinically used to assess to decide whether to infuse more fluid, or stop giving fluid to the patient.

Protocolized approaches for examination with ultrasound have been described for use in various conditions such as the bedside lung ultrasound in emergency (BLUE) and fluid administration limited by lung sonography (FALLS).

TRANSTHORACIC ECHOCARDIOGRAPHY

Ultrasound performed by anesthesiologists in the perioperative period basically involves four standardized acoustic views for cardiopulmonary screening and monitoring **(Table 1 and Fig. 8)**. These are enough to evaluate basic hemodynamic variables such as assessment of preload and preload responsiveness, chamber size and contractility, and regional wall motion abnormalities. Transthoracic echocardiography (TTE) is vital tool for perioperative evaluation of the cardiovascular status and assessment of rapidly deteriorating patients.

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Table 1: Basic transthoracic views.

View	*Probe position*	*View good for*
PLAX (parasternal long axis)	Left parasternal (Probe marker right shoulder)	LA, LV size and function MV function RVOT size LVOT
PSAX (parasternal short axis)	Left parasternal (Probe marker left shoulder)	RV, LV size and function, MV assessment, RWMA
Apical 4C (apical 4 chamber)	Apex	RA, RV, LA, LV size and function TV, MV function and gradients Pericardial pathologies
Apical 5C (apical 5 chamber)	Apex	Along with A4C, LVOT VTI, CO
Subcostal	Xiphisternum	A4C applications plus volume assessment, bubble study

(CO: cardiac output; LA: left atrium; LV: left ventricle; LVOT: left ventricular outflow tract; MV: mitral valve; RVOT: right ventricular outflow tract; RA: right atrium; RV: right ventricle; RVOT: right ventricular outflow tract; TV: tricuspid valve; VTI: velocity time integral)

Rapid assessment of etiology of perioperative shock such as cardiac tamponade, hypovolemia, left ventricular (LV) dysfunction, acute cor pulmonale, and acute respiratory failure can be easily done with ultrasound. Contractility and left ventricle function can be assessed by eyeballing the ventricle and classified as normal, mild, moderate, and severe.

Various protocols have been standardized for assessment of patents in shock, such as rapid ultrasound in shock (RUSH), focus-assessed transthoracic echocardiography (FATE), etc. TTE can be quickly used in cardiac arrest situation without interruption of advanced cardiac life support. It helps to evaluate the cause of arrest, especially in pulseless electrical activity (PEA) by diagnosing potentially treatable causes such as cardiac tamponade, tension pneumothorax, and pulmonary embolism.

Studies have shown that clinicians can be trained in a short period of time to determine left ventricular function, determine intravascular fluid status, detect pericardial effusion, and identify valvular pathologies.

TRANSESOPHAGEAL ECHOCARDIOGRAPHY

The perioperative use of transesophageal echocardiography (TEE) started with cardiac anesthesiology, however it is now increasingly used in noncardiac surgeries. TEE provides high-resolution images of the posterior cardiac structures, and gives distinct advantage over TTE in the perioperative period. Perioperative TEE is indicated and increasingly used in patients with unexpected or unexplained hemodynamic instability. American Society of Anesthesiologists/American Society of Echocardiography (ASA/ASE) consensus statement for perioperative TEE examination suggests 11 views for basic hemodynamic assessment. The TEE views are obtained through esophageal and gastric windows giving us commonly practiced mid-esophageal (ME) views and transgastric (TG) views **(Fig. 9)**.

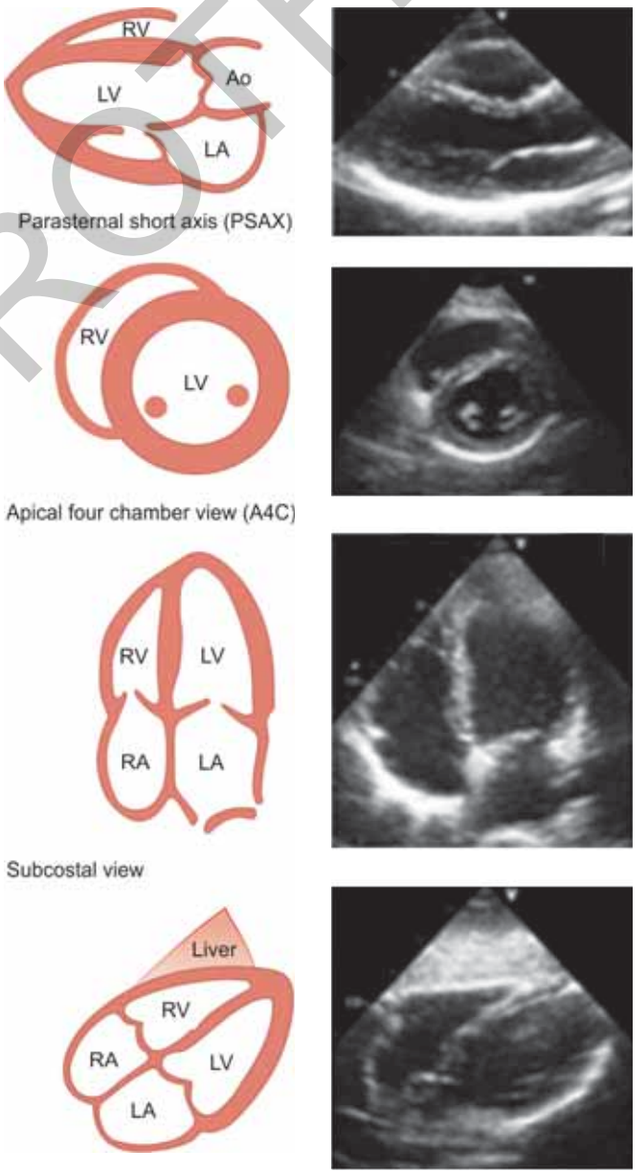

Fig. 8: Parasternal long-axis view (PLAX).
(Ao: aorta; LA: left atrium; LV: left ventricle; RA: right atrium; RV: right ventricle)

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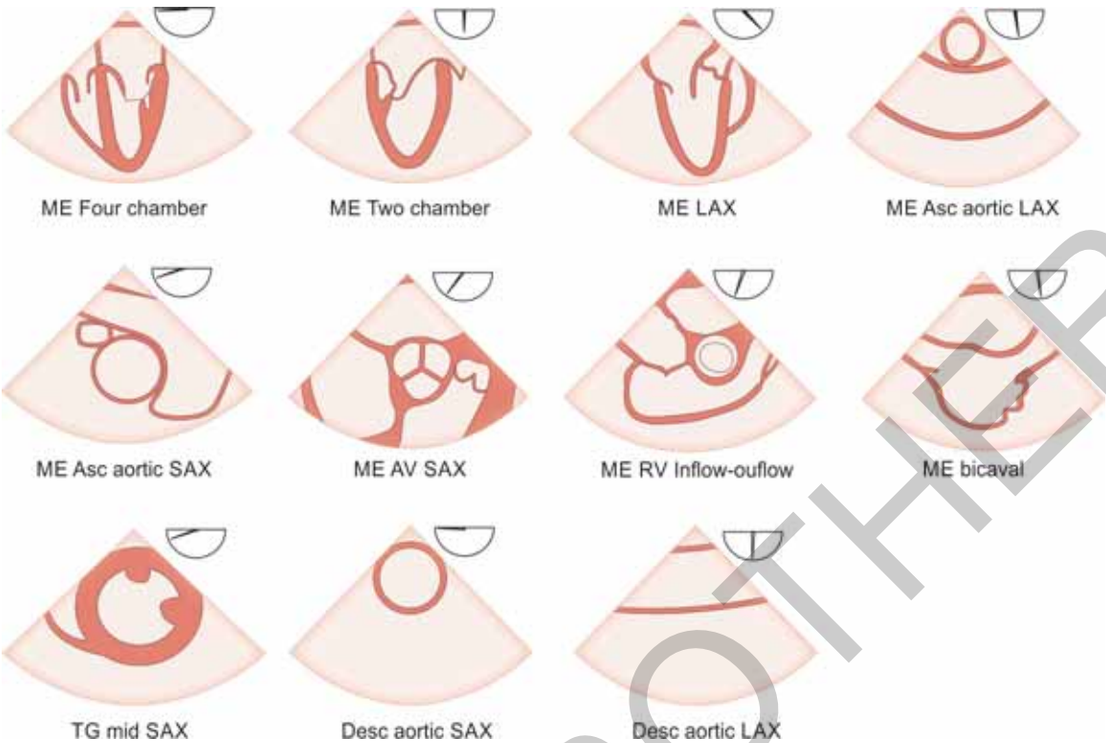

Fig. 9: Transesophageal echo views.
(AV: aortic valve; LAX: long axis; ME: midesophageal; RV: right ventricle; SAX: short axis; TG: transgastric)

GASTRIC ULTRASOUND

One of major perioperative concerns for anesthesiologists is aspiration of gastric contents, which is associated with up to 20% incidence of hospital mortality. Though patients present with varied fasting status, even adequately fasted patients may not have empty stomach due to conditions leading to delayed gastric emptying. Gastric antrum is amenable to sonographic examination as it lies between the left lobe of the liver anteriorly and the pancreas posteriorly in a sagittal or parasagittal scanning plane in the epigastrium. Ultrasound assessment of the gastric antrum can be done in supine and right lateral decubitus (RLD) position. Studies have shown numerical correlation between an antral cross-sectional area (CSA) and the total volume of gastric fluid.

Ultrasound helps in semiquantitative grading of gastric volume. Normally baseline gastric secretion is approximately 1.5 mL/kg (100–120 mL in an average adult). This carries a low risk of pulmonary aspiration.

Grade 0: When gastric antrum is empty in both supine and lateral positions (suggests minimal volume and low risk of aspiration).

Grade 1: When gastric antrum is empty in supine and clear fluids in lateral position (suggests volume <1.5 mL/kg and low risk of aspiration).

Grade 2: When gastric antrum shows fluid in both the supine and lateral positions (suggests volume >1.5 mL/kg and high risk of aspiration).

The curved low-frequency transducer (2–5 MHz) is best for gastric ultrasound.

ULTRASOUND IN NEUROANESTHESIA

Ultrasound has gained popularity in assessing elevated intracranial pressure (ICP) and cerebral perfusion pressure in neurology, with applications such as TransCranial Doppler (TCD), TransCranial Color-Coded Duplex Doppler (TCCD), and measurement of optic nerve sheath diameter (ONSD).

Ultrasound can record blood velocities from intracranial arteries by insonation of low-frequency pulsed Doppler waves (2–4 MHz) over acoustic windows such as transorbital, temporal, or submandibular to obtain spectral waveform with peak systolic and diastolic velocities. The cerebral blood flow velocity (CBFV) has been shown to correlate with ICP assessed with measurement of pulsatility index (PI). PI is a ratio between the systolic and diastolic velocities and is not affected by the angle of intonation thus it helps in monitoring ICP.

This is extremely beneficial to detect vasospasm, which is diagnosed when the velocities within the arteries of the circle of Willis exceed a predetermined lower limit of 50 cm/s indicating a high risk for delayed cerebral ischemia.

Other important ultrasound application is measuring ONSD. The optic nerve sheath is in direct continuity with the dura and subarachnoid space of the brain, and because it is distensible, cerebrospinal fluid (CSF) pressure variations influence the volume of ONSD, particularly in the retrobulbar compartment.

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Raised ICP is transmitted to the subarachnoid compartment of the nerve, causing enlargement of the optic nerve sheath and thus enlargement of the ONSD.

With linear high-frequency probe lightly kept on the closed eye, ONSD is measured 3 mm behind the globe, both in the transversal and sagittal planes. The optic nerve is seen as hypoechoic structure extending from the retina posteriorly, while the nerve sheath is little more echogenic surrounding the nerve. ONSD measurements have been compared with invasively measured ICP. The cutoff for normal ICP (20 mm Hg) correlates with ONSD of 4.8–6 mm.

Ultrasound can also be used for measuring pupillary light reflex (PLR), especially in trauma settings and M-mode measurements are used to measure the constriction velocity of the PLR.

SUMMARY

Ultrasound applications in anesthesiology are emerging to improve the quality of care, providing diagnostic and monitoring capabilities, and enabling optimization of perioperative management. Ultrasound plays pivotal role in management of various emergencies such as hypoxia, hypotension, dyspnea, etc. Ultrasound will be the future stethoscope for the anesthetist.

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CHAPTER

40

Anesthesia for Cancer Surgery

Jigeeshu V Divatia, Kaizeen Daruwalla

HIGHLIGHTS

- Perioperative care of the cancer patient requires an understanding of the effects of cancer and cancer therapies on various organ systems of the body.
- Prehabilitation includes optimization of medical conditions and nutrition, physical exercise, and psychological support.
- Anesthetic techniques should be tailored to facilitate enhanced recovery after surgery, early return to intended oncological therapy and prevention of chronic post-surgical pain.
- The effect of anesthetic techniques on cancer recurrence and metastases is an area of ongoing research.
- Palliative care should be integrated early in the management of the cancer patient.
- Oncoanesthesiology is emerging as an exciting new speciality.

INTRODUCTION

Cancer is the second leading cause of death worldwide and is responsible for 1 out of every 6 deaths. The World Health Organization (WHO) predicts 22 million annual new cancer diagnoses globally by 2030. Around 60–80% of cancer patients are likely to require anesthesia for various diagnostic, therapeutic, or palliative procedures. Perioperative care in cancer patients requires dedicated and specialized care with in-depth understanding of cancer biology, effect of the cancer treatments on various systems, and the implications for anesthetic management. This has given birth to the distinctive subspecialty of onco-anesthesiology. This chapter provides a brief overview of onco-anesthesiology, including implications of chemotherapy, radiotherapy, effect of various anesthetic agents on cancer recurrence, evidence-based preoperative optimization, intraoperative strategies, and postoperative pain management.

PATHOPHYSIOLOGIC DISTURBANCES ASSOCIATED WITH CANCER

Several pathophysiological disturbances affecting various systems may occur in cancer patients. These are summarized in **Box 1**.

Box 1: Pathophysiologic manifestations of cancer.

- Fever
- Anorexia and weight loss
- Lactic acidosis
- Anemia or polycythemia
- Thrombocytopenia
- Coagulopathies
- Neuromuscular abnormalities
- Ectopic hormone production
- Hypercalcemia
- Adrenal insufficiency
- Nephrotic syndrome
- Ureteral obstruction
- Pulmonary osteoarthropathy
- Obstruction of superior vena cava
- Pericardial effusion and tamponade
- Spinal cord compression
- Brain metastases

Fever can accompany any type of cancer but is particularly likely when metastases to the liver have occurred. Mechanisms include tumor necrosis, inflammation, the release of toxic products by the tumor cells, and the production of endogenous pyrogens.

Anorexia and weight loss may be a direct consequence of the tumor or result from the psychological impact of the malignancy.

Lactic acidosis maybe a feature of rapidly proliferating tumors, such as the acute leukemias and lymphomas. Acidosis results from increased anerobic glycolysis of the hypoxic proliferating tumor cells, especially when hepatic function is concomitantly impaired. Tumors that cause lactic acidosis are often responsive to chemotherapy, if the life-threatening acidosis is first corrected.

Anemia may occur due to direct effects of the cancer, such as gastrointestinal (GI) ulceration with bleeding or replacement of the bone marrow. Chemotherapeutic drugs depress the activity of the bone marrow. Other causes include shortened erythrocyte survival, hypersplenism, autoimmune hemolysis, and nutrient deficiency. Increased amounts of erythropoietin produced by hypernephromas or hepatomas can increase red cell mass.

Thrombocytopenia: Unexplained thrombocytopenia is an indication to search for an occult neoplasm.

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Thrombocytopenia that cannot be attributed to therapy with chemotherapeutic drugs may reflect hypersplenism or disseminated intravascular coagulation.

Coagulopathies: Disseminated intravascular coagulation may occur with advanced cancer, especially in the presence of hepatic metastases. Recurrent venous thrombosis occurs due to increased coagulability in many cancers, especially in pancreatic neoplasms.

Thrombosis and cancer patients: Cancer patients have an increased risk of venous thromboembolism (VTE), arterial thrombosis, and chronic disseminated intravascular coagulopathy. Cancer is one of the major risk factors of VTE and accounts for 20% of deaths associated with VTE. Other risk factors for VTE include immobilization, obesity, and hormone therapy. Prolonged surgery along with prolonged immobilization in obese cancer patients further increases the risk of VTE. The incidence of VTE is around 0.5% in cancer patients as compared to 0.1% in the general population.

Neuromuscular abnormalities occur in 5–10% of patients with cancer. The most common manifestation is muscle weakness (myasthenic syndrome) associated with carcinoma of the lung.

Metabolic and endocrine abnormalities: Hypercalcemia is most likely to occur as a result of metastases to bone, with subsequent release of calcium. Occasionally, it is the result of ectopic parathormone-like-hormone production, with tumors that arise from the kidneys, lung, pancreas, or ovary. Excessive calcitriol production is seen with lymphomas.

Hyperuricemia is characteristically associated with leukemia in which there is a large tumor mass, and chemotherapeutic drugs have produced destruction of the malignant cells, resulting in the acute tumor lysis syndrome. Acute renal failure can accompany hyperuricemia, particularly if the serum uric acid concentration exceeds about 15 mg/100 mL.

Adrenal insufficiency may occasionally be caused by complete replacement of the adrenal gland by metastatic tumor. More often, there is a relative adrenal insufficiency, due to the partial replacement of the adrenal cortex by tumor, or suppression of adrenal cortex function by prolonged treatment with corticosteroids. Insufficiency is most often seen in patients with metastatic disease due to melanoma, retroperitoneal tumors, carcinoma of the lung, and carcinoma of the breast. The stress of the perioperative period may unmask adrenal insufficiency. Clinical manifestations include fatigue, dehydration, oliguria, hypoglycemia, hyponatremia, and cardiovascular collapse.

Ectopic hormones may be secreted by some tumors. These are summarized in **Table 1**.

Nephrotic syndrome may occur due to deposition of antigen-antibody complexes on the glomerular capillary membrane.

Table 1: Ectopic hormone production.

Hormone	*Associated cancer*	*Manifestation*
Adrenocorticotropic hormone	Lung (small cell) Thyroid (medullary) Thymoma Carcinoid Non-beta islet cell of pancreas	Cushing's syndrome
Antidiuretic hormone	Lung (small cell) Pancreas Lymphomas	Water intoxication
Gonadotropin	Lung (large cell) Ovary Adrenal	Gynecomastia Precocious puberty
Melanocyte-stimulating hormone	Lung (small cell)	Hyperpigmentation
Parathormone	Renal Lung (squamous) Pancreas Ovary	Hyperparathyroidism
Thyroid-stimulating hormone	Choriocarcinoma Testicular (embryonal) Hydatidiform mole	Hyperthyroidism
Thyrocalcitonin	Thyroid (medullary)	Hypocalcemia
Insulin	Retroperitoneal tumors	Hypoglycemia

Ureteral obstruction: Unilateral obstruction may occur with retroperitoneal tumors, including lymphomas and testicular cancer. Bilateral ureteral obstruction usually accompanies a known pelvic neoplasm such as gynecologic tumor or carcinoma of the bladder or prostate. It may be asymptomatic until renal failure sets in.

Pulmonary osteoarthropathy is seen in carcinoma of the lung.

Obstruction of the superior vena cava: The principal manifestation is engorgement of the veins above the waist, particularly the jugular veins. It is commonly seen in carcinoma of the lung and anterior mediastinal tumors. It may be accompanied by airway obstruction and cerebral edema.

Brain metastases: The incidence of brain metastases is between 25 and 50% for malignancies originating in the breast, kidney, and thyroid gland. Whole-brain radiation and administration of dexamethasone to relieve cerebral edema may be effective in reducing the size and subsequent neurologic effects produced by brain metastases. Surgical excision of an isolated metastasis is indicated when the brain scan shows no other lesions.

ONCOANESTHESIOLOGY

Oncoanesthesiology is a growing subspecialty that deals with preoperative optimization, intraoperative management, postoperative intensive care, and pain management (acute and chronic) of cancer patients posted for surgery. The essential elements of onco-anesthesiology are summarized in **Box 2**.

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Atul P Kulkarni MD (Anesthesiology) FISCCM PGDHHM FICCM is currently Professor and Head in the Division of Critical Care, Department of Anesthesiology, Critical Care and Pain at the Tata Memorial Hospital, Homi Bhabha National Institute, Mumbai, Maharashtra, India. A recognized postgraduate teacher for MD (Anesthesiology), he is now a teacher for DM (Critical Care Medicine). A postgraduate diploma holder in postgraduate diploma in health and healthcare management, he has received training in intensive care at St George Hospital, Sydney in 2002–2003. He has participated in many conferences on critical care and anesthesiology at international, national, and state levels. He was the Organizing Secretary for anesthesia review course since 2004–2018. He was Treasurer of Indian Society of Critical Care Medicine during 2004–2010. He was later General Secretary of Indian Society of Critical Care Medicine (2010–2014) before he took over as President of Indian Society of Critical Care Medicine (2015–2017) and the Chancellor, Indian College of Critical Care Medicine. He was a Member of the Editorial Board of Indian Journal of Critical Care Medicine (IJCCM) and Reviewer for IJCCM and Indian Journal of Anaesthesia (IJA). He is also the Past President of Association of South Asian Association for Regional Cooperation (SAARC) Critical Care Societies and Secretary General. After serving as the honorary Secretary General of the Asia Pacific Association of Critical Care Medicine, he took over as the President of the prestigious organization. Currently he is the Editor-in-Chief of the Indian Journal of Critical Care Medicine.

Vandana Agarwal MD (Anesthesiology) FRCA is Professor, Department of Anesthesiology, Critical Care and Pain at the Tata Memorial Hospital, Homi Bhabha National Institute, Mumbai, Maharashtra, India. After postgraduation, she trained in the UK and became a Fellow of Royal College of Anaesthetists by examinations. She is a recognized postgraduate teacher. She is clinical lead for hepato-pancreato-biliary anesthesia. She has been Secretary of ISCCM (2014–2016, and 2018–2019) and Treasurer (2016–2017). She has over 25 publications in national and international journals and many book chapters to her credit in anesthesia and intensive care. She has delivered many lectures on various topics in anesthesia, and intensive care in several national and state level conferences.

Vijaya P Patil MD (Anesthesiology) Dip (Hosp Adminis) is currently Professor and Head of the Division of Clinical Anesthesia, Department of Anesthesiology, Critical Care and Pain at the Tata Memorial Hospital, Homi Bhabha National Institute, Mumbai, Maharashtra, India. She is recognized postgraduate teacher for MD (Anesthesiology). She has also completed Diploma in Hospital Management from reputed Tata Institute of Social Sciences. Currently she is a Member of the Editorial Board of Indian Journal of Critical Care Medicine (IJCCM) and Reviewer for IJCCM and Indian Journal of Anaesthesia (IJA).

Jigeeshu V Divatia MD (Anesthesiology) FISCCM FICCM is Professor and Head, Department of Anesthesiology, Critical Care and Pain at the Tata Memorial Hospital, Homi Bhabha National Institute, Mumbai, Maharashtra, India. A postgraduate diploma holder in medicolegal systems, he has received training in Intensive Care at St George Hospital, Sydney in 1995–1996. He is a Past President of the Indian Society of Critical Care Medicine. He is also the Past Editor-in-Chief, Indian Journal of Anaesthesia (IJA). He was the Chairman, Scientific Committee, ISACON 2011, Mumbai. He has been conferred with the Fellowship of the ISCCM (FISCCM) in 2010 and of the Indian College of Critical Care Medicine (FICCM) in 2012. He has also received the SCCM (USA) Presidential Citation in 2010 and 2011. He has over 150 publications to his credit in national and international journals. He is Member of Editorial Board, Journal of Intensive Care Medicine, Indian Journal of Anaesthesia (IJA) and Indian Journal of Critical Care Medicine. He is also Referee for the Lancet, PLOS ONE, and the Indian Journal of Medical Research, He has presented many papers in several international, national, and state level conferences.

Printed in India

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ISBN 978-93-5465-204-2

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