BLOOD CULTURE

Its Role in the Management of the Septic Patient
Types of Blood Stream Infections

- **Transient:**
  Usually follows mechanical or surgical manipulation of infected tissue, dental procedures, cystoscopy etc.

- **Intermittent:**
  Typically seen with undrained abscesses or in association with localized infections such as pneumonia, urinary tract infections, and central nervous system infections.

- **Continuous:**
  Observed with intravascular infections, e.g. infective endocarditis, septic thrombophlebitis, mycotic aneurysm.

Collection Sites (1/3)

• Peripheral vein or artery

No true advantage to arterial over venous specimens
Venous specimen collection is convenient

• Intravenous catheters

More likely to contain *Staphylococcus epidermidis* than blood cultured by percutaneous venipuncture

Umbilical (naval) catheters are believed to be a reliable source for blood specimens during the early hours of life (< 12h)
Collection Sites (2 / 3)

• Bone marrow

May be positive when peripheral blood is negative (e.g. Brucellosis, bacterial endocarditis, typhoid fever)

Only to be considered if these infections are suspected, and routine cultures are negative
• Neonatal Skin Stick (Heelstick)

Considered at least as sensitive as venous cultures, even though much smaller volumes are collected (typically < 0.5 ml)

Subject to contamination if not done properly

Optimum volume for pediatric specimens and number of cultures in neonates are under debate; several studies have shown:

- Increased recovery if 2 ml is collected vs. 1 ml
- up to 55 % increase in recovery rate if a second culture is drawn
Skin Preparation

“Poor skin preparation prior to drawing blood cultures is the most common cause of culture contamination.”


“False-positive blood cultures may be associated with increased length of hospital stay and increased pharmacy and laboratory charges.”

Dunne et al. CUMITECH Blood Cultures III; 1997, ASM Press
Skin Preparation

- 70% alcohol for 30 sec from centre to periphery
- 2% iodine tincture for 60 sec or 10% povidone for 120 sec
- Allow to dry completely
- Sterile gloves preferred
- Repalpitation of vein only with disinfected finger
- Change needle if unsuccessful
- Cleanse rubber stopper of the blood culture bottle with 70% alcohol before blood inoculation

Dunne et al. CUMITECH Blood Cultures III; 1997, ASM Press
Timing of Blood Cultures

• Fever and chills occur appr. 1 h after the microbial invasion of the bloodstream
  – **Optimal time**: just before anticipated onset of the chill or fever, **but** difficult to predict

• Typically collected **as soon as possible** after the onset of fever or chills or whenever serious infection is suspected

Dunne et al. CUMITECH Blood Cultures III; 1997, ASM Press
Timing of Blood Cultures

- Collection, whenever possible, prior to the administration of antimicrobial agents.
- Simultaneous collection of two to three 20 - 30 ml blood specimens in the initial evaluation.

  Dunne et al. CUMITECH Blood Cultures III; 1997, ASM Press

- There is no significant difference in the microbial recovery, whether blood cultures sets are drawn simultaneously or with an interval period between sets.
- Potential exception: Endocarditis

  Li et al. JCM 1994, 32, 2829
Timing of Blood Cultures

- Patients with fungemia who are on antifungal therapy should have repeat cultures done to document clearance of the organism.

- Similarly, patients with *S. aureus* bacteremia (w/wo endocarditis) should have repeat blood cultures performed after treatment is started to control clearance.

Sites for obtaining Blood Cultures

“Venipuncture is the method most commonly used”


“Whenver possible, blood for culture should not be drawn through an indwelling intravenous or intra-arterial catheter”

Reason: Potential risk of higher contaminations!

Dunne et al. CUMITECH Blood Cultures III; 1997, ASM Press
“The volume of blood drawn per culture is the single most important variable in recovering microorganisms from the blood of bacteremic or fungemic patients”.

“Laboratories should routinely monitor the volume of blood cultured as a quality assurance activity…”

Dunne et al. CUMITECH Blood Cultures III; 1997, ASM Press
Concentration of Organisms in Bacteremia

In Adults:

- Gram Negative Bacteremia: <1 to 10 organisms /mL
- Gram Positive Bacteremia: 1 to 300 organisms /mL

In Children:

- 75% of children: > 100 organisms /mL

Each ml of blood, up to 10 ml, can increase the sensitivity of the blood culture by 3 - 5%.

Betty A. Forbes, Diagnostic Microbiology, 1998

Optimal Volume of Blood for Culture

• Adults:
  - 20 ml per set (two bottles)

• Pediatric
  - Neonates 1-2 ml per bottle
  - Infants and children 2-5 ml per bottle
  - Adolescents 10-20 ml per set


“A blood culture is defined as the blood withdrawn from a single venipuncture, whether, that blood is inoculated into one or multiple bottles.”

Dunne et al. CUMITECH Blood Cultures III; 1997, ASM Press
"With adequate volume of blood, 2 - 3 blood culture sets are sufficient to detect nearly all episodes of bacteremia and fungemia"  

Dunne et al. CUMITECH Blood Cultures III; 1997, ASM Press
Anaerobic Blood Cultures
Are they still indicated?

Common traditional BC set:
• 10 ml blood for aerobic BC + 10 ml blood for anaerobic BC

Alternative selective approach:
• 10 ml blood for aerobic BC + 10 ml blood for aerobic BC
  ± 10 ml of blood for fungal BC
  ± 10 ml of blood for anaerobic BC
  ± 10 ml of blood for mycobacterial BC

“Anaerobic blood cultures should be selectively ordered in patients at risk for anaerobic infections.”
“Several studies have found no significant difference in the isolation of clinically significant organisms with 5 versus 7 days of incubation using an automated blood culture system.”

Transport from Bed Side to the Lab

- Prior to transport, vials should be properly identified.
- Transport time should be as fast as possible.
- Transport temperatures should not be extreme.
  - Preferably at RT
  - Never frozen nor refrigerated
  - Not higher than normal body temperature.
- Vial leakage should be considered all the time.
  - Use adequate transport containers.
  - Wear gloves.
Duration of Blood Cultures

Fastidious Bacteria

Brucellosis:
7 days of incubation using an automated blood culture system

Endocarditis (HACEK group):
Extended incubation (2-4 weeks) plus blind subcultures

Mycobacteria:
Extended incubation (up to 6 weeks)

Mycoplasma:
Need to neutralize the inhibitory effect of SPS (e.g. addition of gelatine)

Dunne et al. CUMITECH Blood Cultures III; 1997, ASM Press
Reporting of Blood Cultures

Positive Blood Cultures:
 immediate verbal report to the physician incl.
 Gram morphology and no. of positive BC

Negative Blood Cultures:
 intermittently, after 24 / 48 / 72 hrs
 finally, after complete incubation period

Dunne et al. CUMITECH Blood Cultures III; 1997, ASM Press
Manual Examination

All negative bottles should be examined for bacterial activity

- Turbidity
- Hemolysis
- Gas production
- Pellicle formation
- Clotting
- Colony formation

The finding of any of the above features should prompt an immediate Gram stained smear of the broth or colonies in the suspected bottle and a very careful visual inspection of any other bottle of the set.
“Microorganisms that almost always (>90%) represent true infection include:”

- Staphylococcus aureus
- Escherichia coli
- Pseudomonas aeruginosa
- Enterobacteriaceae
- Streptococcus pneumoniae
- Candida albicans

Blood Culture Contamination

“If blood cultures are collected properly, no more than 2 to 3% of all blood cultures should be contaminated.”

“Isolates from blood that rarely (<5%) represent true infection include:”

– Corynebacterium spp.
– Propionibacterium acnes
– Bacillus spp.

We conclude that the number of positive culture bottles cannot reliably predict the clinical significance of the CNS isolated and, therefore, should not be used as criterion for determining whether or not an isolate represents true infection or contamination.

Mirrett et al. 2001 JCM 39; 3279
Blood Culture should start with Safe Blood Collection

- Needle-stick injuries present a serious occupational hazard for health care workers
- More than 8 million health care workers in the US are exposed to sharps
- Precise data are not available on the number of annual needle sticks, however, estimates indicate 600,000 – 800,000 occur annually in the US
Blood Culture should start with Safe Blood Collection

BD Vacutainer™ System
Safe blood collection sets or syringes

“Routine use of the Vacutainer blood collecting system in our hospital may help to keep contamination low. In addition, this system reduces the risk of inadvertent needle sticks and the exposure of health care workers to blood-borne infections.”

Rohner et al. 1997, JCM;35,2634
“No one medium or system is capable of detecting all microorganisms.”

Weinstein M.P. 1996 CID; 23,40
BD offers special media for:

- Aerobes
- Anaerobes
- Yeasts/Fungi
- Mycobacteria
- Pediatric patients

Some media contain resins in order to absorb antibiotics
Resins

- are non-ionic and cationic exchangers that neutralize many different antibiotics which might be present due to the pretreatment of the patient
- help to lyse blood cells so that intra-cellular organisms are set free
- provide the organisms with growth-centres to enhance speed and recovery rate
“Resin media have increased the overall rate of isolation of organisms from patients receiving or not receiving antibiotics.”

Jorgensen et al. 1997, JCM;35,53

“With resin containing media..., more microorganisms could be isolated, in general, than with the corresponding standard (nonresin) media”.

Rohner et al. 1997, JCM;35,2634

“In the present study, significantly more pathogenic microorganisms were recovered from Plus Anaerobic/F bottles than from Standard Anaerobic/F bottles”.

Wilson et al. 2001, JCM;39,983
Media for adults: 3 - 10 ml blood

BACTEC Plus Aerobic/F
BACTEC Plus Anaerobic/F

BACTEC PEDS Plus/F

Media for pediatric patients: 1 - 3 ml blood

False-positivity rate: 0.5%** - 0.65%*
False-negativity rate: 0.12%* - 0.2%***

**Smith et al. 1995 JCM;33,d1905
***Ziegler et al. 1998 JCM;36,657
BACTEC Lytic/10 Anaerobic/F

Contains 0.26% saponin as a lysing agent.
Provides faster time to detection for facultative and anaerobic organisms compared to BACTEC Anaerobic Plus/F

“Plus aerobic/F and Lytic anaerobic/F proved to be a valuable pair of blood culture media. Plus aerobic/F performs better for patients under antibiotic treatment, due to the antimicrobial-neutralizing effect of resins. For patients without antibiotic therapy, more organisms could be isolated from Lytic anaerobic/F due to cell lysis.”

Rohner et al. 1997, JCM;35,2634
BACTEC Mycosis IC/F

A fungus selective medium containing saponin, chloramphenicol, and tobramycin. Developed for immunosuppressed patients.

“This study shows that the use of the Mycosis IC/F medium on the Bactec 9240 system should speed up the diagnosis of systemic fungal infections and allow early initiation of antifungal therapy, which is critical in reducing the high mortality rates in cancer, burn, surgical, and neonatal intensive care patients.”

BACTEC Mycosis IC/F

Average Time to Detection of 43 Fungi

- Mycosis/IC F
- Aerobic/F Plus

BACTEC Myco F/Lytic

Specially developed for the recovery of mycobacteria and fungi. Very useful for AIDS patients and other immunocompromised patients.

“In summary, Myco F/Lytic is an excellent medium for the recovery of fungi, mycobacteria, and bacteria: however, the time to detection of H. capsulatum is increased.”

Fuller et al. 2001 JCM; 39, 2933

In summary, the combination of MYCO/F Lytic medium and the BACTEC 9240 instrument is an excellent blood culture system for the growth and detection of mycobacteria.

Waite and Woods 1998 JCM; 39, 117
DVE - Delayed Vial Entry

The Problem:
“Because of off-site collection or restricted lab operating hours, there may be a substantial delay between blood culture inoculation and entry into the instrument.”

Chapin and Lauderdale 1996, JCM;34,543

The Solution:
BACTEC™ blood culture systems with proven DVE capabilities
“Bactec 9240 vials may be incubated at 35°C for up to 24 h with a minimal loss of detection (97.9%), and vials delayed for more than 24 h should remain at RT for optimal recovery of organism growth.”

Chapin and Lauderdale 1996, JCM;34,543
“Our data show that 4 days of incubation were sufficient to recover all clinically relevant bacteria and 6 days were required to recover all clinically relevant yeasts.”

Reisner and Woods (1999) JCM, 24: 379
Automated vs. Manual Blood Culture

Clinical study, 1442 blood culture sets. 16.14% of the samples were positive.

Cumulative Detection Rate (%)

- Automated
- Manual

Time (hours)

Saleh, A.F. et al. 8th ECCMID 1997
BD BACTEC 9050 System

BACTEC 9050
50 bottles per instrument
25 patient samples
5 -10 new samples per day
2-3600 samples per year

Need to calculate per customer!

For laboratories that process fewer than 150 blood culture vials per month.
BD BACTEC 9120 / 9240 System

BD BACTEC 9120
- 120 bottles per instrument
- 12 new samples per day
- 5-8000 samples per year

BD BACTEC 9240
- 240 bottles per instrument
- 20-24 new samples per day
- 10-17000 samples per year